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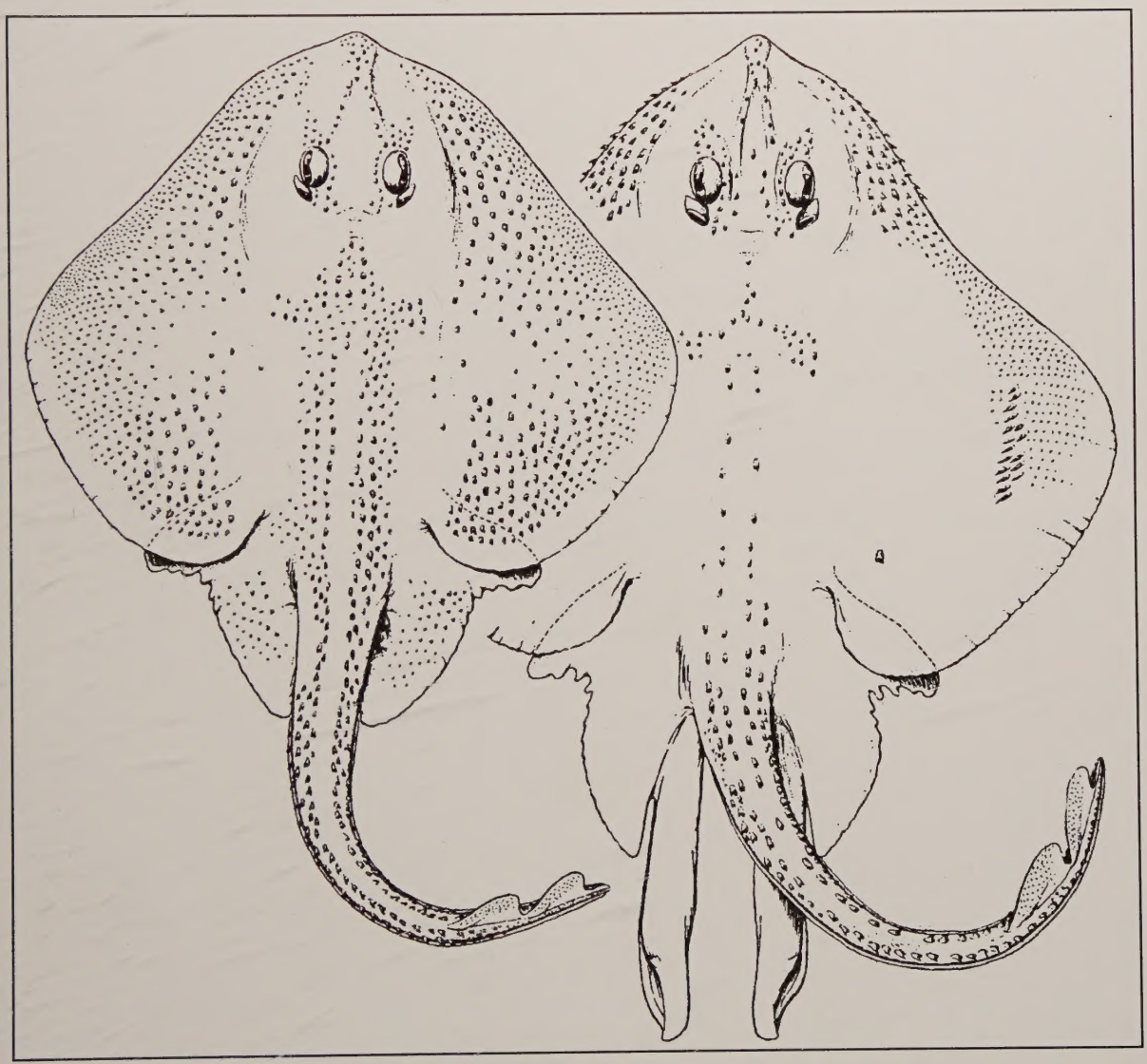

Little Skate, *Leucoraja erinacea*

Marine Fisheries REVIEW

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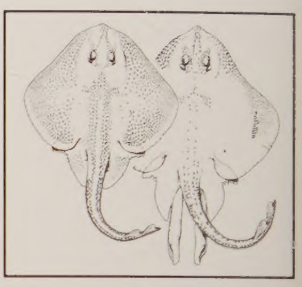

On the cover:
Little skate, *Leucoraja erinacea*, left: female, 17.5 in; right: male, 20 in; From Bigelow and Schroeder (1953), drawing by E. N. Fischer.

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Landings Composition of the Northeast U.S. Skate, Rajidae, Wing Fishery and the Effectiveness of Prohibited Species Regulations

TOBEY H. CURTIS and KATHERINE A. SOSEBEE

ABSTRACT—The skate (Rajidae) fishery off of the northeastern United States is managed as a stock complex of seven species. However, landings have not been reliably reported by species, hindering stock assessments and effective species-level management. This study was designed to characterize regional and interannual variation in the species composition of landings in the skate wing fishery. Port samplers were trained to properly identify skate wings landed at regional seafood dealers. Of the 92,833 skate wings sampled between 2005 and 2012 at ports in Maine, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, over 98% were identified as belonging to winter skate, Leucoraja ocellata. *The wings of thorny skate,* Amblyraja radiata, *and barndoor skate,* Dipturus laevis, *both prohibited species, comprised the remainder of the sampled landings. While illegal landings of prohibited skates were more prevalent in Gulf of Maine ports, compliance with the prohibitions improved during the study period, possibly due to NMFS outreach efforts. These results demonstrate the relative effectiveness of species prohibitions in the skate fishery and may help improve stock assessments for skates.*

Introduction

There are seven species of skates (family Rajidae) commonly encountered on the continental shelf waters off the northeastern United States, including winter skate, *Leucoraja ocellata*; little skate, *L. erinacea*; rosette skate, *L. garmani*; clearnose skate, *Raja eglanteria*; thorny skate, *Amblyraja radiata*; smooth skate, *Malacoraja senta*; and barndoor skate, *Dipturus laevis*. However, only winter and little skates are targeted by regional fisheries, while the other species are largely taken as bycatch (NEFMC, 2003).

Little skates are targeted in a relatively small-scale fishery that provides bait to American lobster, *Homarus americanus*, fishermen. The species that grow to larger maximum sizes, winter (up to 137 cm TL: Sulikowski et al., 2003), thorny (up to 111 cm TL: NEFMC, 2010), and barndoor (up to 152 cm TL: Bigelow and Schroeder, 1953) have historically been harvested for their "wings" (i.e., pectoral fins) to supply seafood markets mainly in Europe (NEFMC, 2003). Little, rosette, clearnose, and smooth skates do not typically reach sizes considered marketable for the skate wing fishery (NEFMC, 2003).

The relative abundance of these species is annually monitored by the NMFS Northeast Fisheries Science Center's (NEFSC) bottom trawl research survey (McEachran and Musick, 1975; Azarovitz et al., 1997). However, fishery catches are not typically reported by species, and the seven species have been managed together as a "stock complex" since 2003, when the New England Fishery Management Council (NEFMC) and NMFS first implemented the fishery management plan for skates (NEFMC, 2003).

The skate wing fishery is centered in New England states, but extends as far south as New Jersey. The majority of landings occur in Massachusetts and Rhode Island and are primarily derived from bottom trawl and gillnet vessels that fish for a mix of groundfish species including Atlantic cod, *Gadus morhua*; flounders (Pleuronectidae); and goosefish, *Lophius americanus* (NEFMC, 2010).

Historically, most skates were discarded, but the increasing value of skate wings in recent years has resulted in increased landings in the United States and worldwide (Fig. 1) (Dulvy and Reynolds, 2002; NEFMC, 2010). Between 1983 and 2002, before management of the skate fishery began, total skate landings in the northeastern United States (including bait and wings) increased from approximately 883 to 16,283 t per year (Fig. 1). Consequently, the overall skate discard rate (the proportion of the total catch that is not retained) in the region has declined from over 90% in the mid-1980's to less than 40% in recent years (NMFS, 2011).

In 2012, the northeastern United States accounted for 59% of total U.S. skate landings (NMFS, 2013). Approximately 4,455 t of skate wings (equivalent to about 10,113 t whole weight) were landed in the region during the 2012 fishing season, valued at $5.3 million. In recent years, skates have represented the dominant elasmobranch resource harvested in U.S. waters, with nationwide skate landings being more than double that of all sharks combined (including "dogfish sharks," Squalidae and Triakidae) in 2012 (NMFS, 2013).

A common challenge in stock complex fisheries is disaggregating catch data and allocating it to the appropri-

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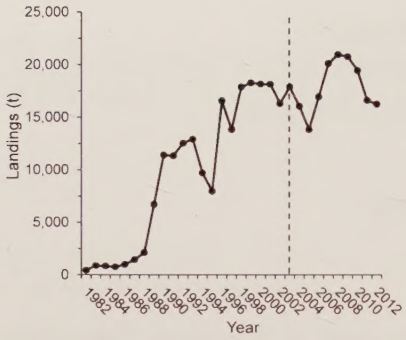


Figure 1.—Total annual landings of skates off the northeastern U.S., 1982–2012. The dashed line indicates the year 2003 in which U.S. management of the skate fishery was implemented.

ate species. This is particularly challenging in elasmobranch fisheries that often include species of similar appearance (Stone et al., 1998; Machado et al., 2004; Figueiredo et al., 2007; Stevenson and Lewis, 2010; Silva et al., 2012). Without accurate species composition information, it is difficult to assess the impacts of fishing on each stock and determine if the exploitation rate is sustainable (Stevens et al., 2000; Figueiredo et al., 2007; Morgan et al., 2009; Ward-Paige et al., 2012). The majority of the skates landed for the wing fishery are processed (wings removed, carcasses discarded) at sea, making species identification even more difficult. One of the initial goals of the Skate FMP was to improve species-level reporting of landings and discards (NEFMC, 2003). Ultimately, this information could lead to more efficient, species-specific assessment and management (Hogan et al., 2013). While investigations into the population dynamics of individual species have been attempted (Frisk et al., 2008; Gedamke et al., 2009; Frisk et al., 2010; NMFS[1, 2]), the difficulty in accurately disaggregating landings and discard estimates to the species level has been a major impediment in assessing individual stocks.

The 2006 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act included

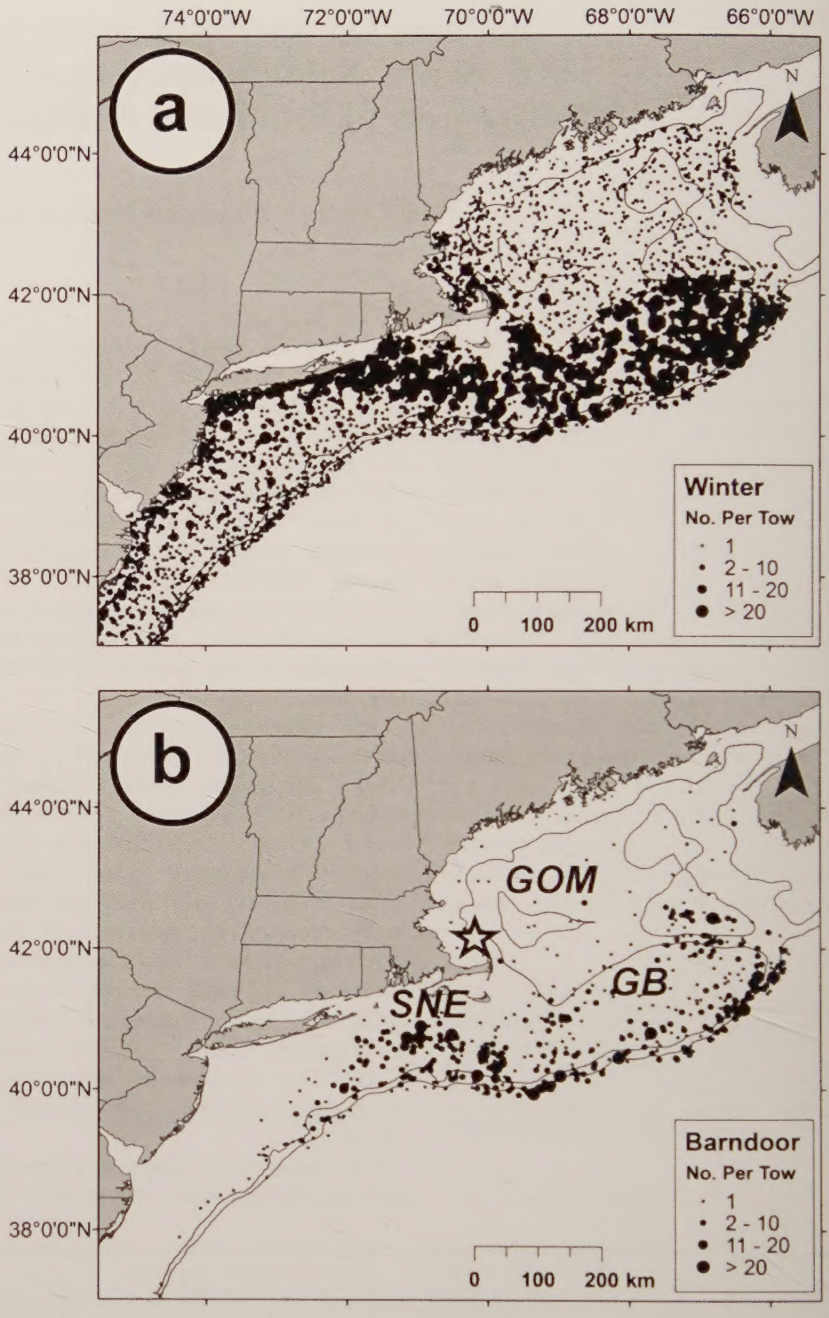
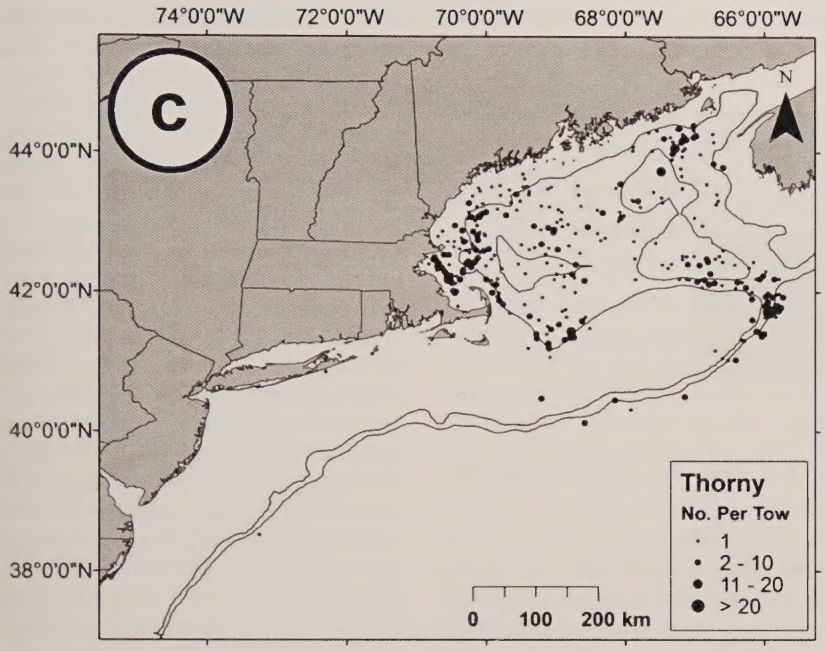


Figure 2.—Distributions of winter (a), barndoor (b), and thorny (c) skates in the study area from the NEFSC spring and autumn bottom trawl surveys, 2005–10. The gray lines represent the 100 and 200 m bathymetric contours. In (b), the star symbol identifies the location of Provincetown, Mass., separating Gulf of Maine (GOM) from Georges Bank (GB) and southern New England (SNE) ports.

[1]NMFS. 2007. Assessment of the northeast skate species complex. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., 44th Northeast Reg. Stock Assessment Workshop (SAW 44), Northeast Fish. Sci. Cent. Ref. Doc. 07-10, 661 p.

[2]NMFS. 2009. The Northeast Data Poor Stocks Working Group Report, December 8–12, 2008 meeting: Part A. Skate species complex, deep sea red crab, Atlantic wolffish, scup, and black sea bass. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Northeast Fish. Sci. Cent. Ref. Doc. 09-02, 180 p.



requirements for annual catch limits (ACL's) that account for scientific and management uncertainty for every federally managed stock or stock complex in the United States. Due to the inability to reliably monitor catch of individual skate species, the NEFMC elected to manage the complex under a single, aggregate ACL. Commercial landing quotas and possession limits were also implemented for the skate wing and bait fisheries, rather than for individual species (NEFMC, 2010).

However, these two fisheries have very different levels of fishing effort, spatial distribution, and species composition (NEFMC, 2003, 2010). While winter skates are considered the primary target of the skate wing fishery (NEFMC, 2003, 2010), the contribution of other species to the landings has not been directly estimated. Indirect methods, such as prorating the NMFS trawl survey species composition in a given area to fishing trips in the same area, have been attempted (NMFS[2]) but remain uncertain and require validation.

The varied life histories, distributions (Fig. 2), and population status of each species suggests that more species-specific management would be preferable (Hogan et al., 2013). For example, winter skate is primarily distributed on Georges Bank and off southern New England and is presently at a high level of relative abundance (Fig. 2a; Frisk et al., 2008, 2010; Hogan et al., 2013). However, thorny and smooth skates, prohibited species distributed in the deeper waters of the Gulf of Maine (Fig. 2c), are very low in relative abundance (Nye et al., 2009; NMFS, 2011). The barndoor skate, once argued to be nearing extinction (Casey and Myers, 1998), is mainly distributed along the southern edge of Georges Bank (Fig. 2b) and has significantly increased in relative abundance in recent years (NMFS, 2011). Managing such species together as a single unit increases scientific and management uncertainty, and potentially reduces the efficiency of the fisheries that harvest them (Reuter et al., 2010; Hogan et al., 2013).

For example, the optimum yield of an abundant stock may have to be partially foregone due to the poor status of another stock within the complex (Hogan et al., 2013). Additionally, the decline of one or more species may be masked by the relative stability of aggregated multi-species catch trends (Dulvy et al., 2000; Wakeford et al., 2004). However, before more species-specific management of the skate complex can be considered, more data are needed on the species composition of landings and discards.

Possession and landing of thorny, smooth, and barndoor skates have been prohibited since 2003 due to their low levels of relative abundance (NEFMC, 2003). All three species were considered overfished and are currently under legally-mandated stock rebuilding programs. Without adequate documentation of the species being landed, it is difficult to quantify the effectiveness of these possession prohibitions. Thorny skate is of particular concern due to its declining survey biomass and overfished condition in U.S. waters (Nye et al., 2009; NMFS[2]), and the degree to which this species is being protected is not known. Thorny skate is categorized as a "Species of Concern" by the NMFS Protected Resources Division, and it is also listed as "Critically Endangered" in U.S. waters by the IUCN (Kulka et al., 2009). Given its vulnerable life history characteristics (Sulikowski et al., 2005, 2006), even small amounts of fishing mortality could significantly hinder the thorny skate's recovery in U.S. waters.

On 22 August 2007, due to concerns that some vessels were still landing thorny skates, NMFS issued a letter to all commercial skate permit holders increasing awareness of the prohibited species regulations.[3] However, whether this outreach effort resulted in any measurable impact on fishing behavior has not previously been assessed.

While more species- or region-specific catch limits may be warranted for the skate complex (Hogan et al., 2013), it is not known if current fishery-dependent monitoring capabilities would be sufficient to make such a transition. The purpose of this study was to quantify the species composition of landings in the skate wing fishery by sampling the wings landed

[3]Letter is available online at: http://www.greateratlantic.fisheries.noaa.gov/nero/nr/nr07.html.

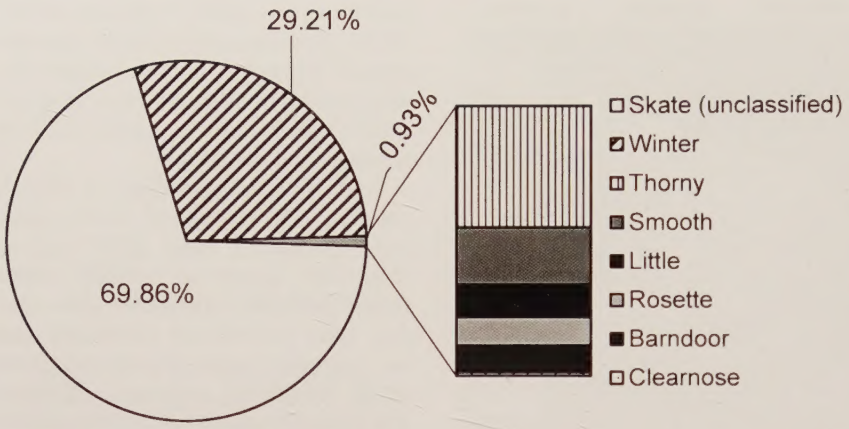


Figure 3.—Species composition of northeastern U.S. skate wing landings as reported by seafood dealers, 2005–12.

at northeast U.S. fishing ports. This investigation will help better characterize the landings portion of the total catch in the skate wing fishery and help determine if prohibited species regulations are adequately enforced.

Materials and Methods

Skate wings were sampled at ports in Maine, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, including the dominant ports of the skate wing fishery (NEFMC, 2010). Sampling effort was not standardized across ports, months, or years, but occurred opportunistically in conjunction with routine port sampling of fishery harvests conducted by NMFS in this region. However, sampling was comprehensive during the study period, with samples occurring in every month of the year across the region. At the point of landing, NMFS port samplers trained in skate species identification examined wings as they were being offloaded from fishing vessels. Unique characteristics on the pectoral fins, such as coloration, spotting patterns, and spines, allowed samplers to differentiate between the various species (Collette and Klein-MacPhee, 2002), and species identification guides were readily available.

Totes of unsorted skate wings were randomly selected and set aside for sampling. A typical tote can contain up to about 68 kg of skate wings. All of the wings in each tote were identified, counted, and weighed by species. Mean individual wing weights were calculated for each species. Given the distinct differences between the wings of the various species and training using whole skate specimens, confidence in port sampler identification was high.

The frequency of each species in the landings was compared between years (2005–12) and port regions and were expressed as percentages of the total number of sampled wings. Due to the distinct biogeographic boundary extending from Cape Cod to Georges Bank, and the different skate species assemblages associated with that boundary (Fig. 2; McEachran and Musick, 1975; Collette and Klein-MacPhee, 2002), the sampling area was divided into two regions. Gulf of Maine (GOM) ports were those extending from Portland, Maine, to Provincetown, Mass., on Cape Cod. Georges Bank/southern New England (GB/SNE) ports included all ports south of Provincetown, Mass. Vessels landing in GOM ports predominantly fish in areas characterized by the GOM skate species assemblage (although a minority of trips that land in GOM ports also fish on GB), and vessels landing in ports south of that region primarily fish in areas characterized by the GB/SNE skate species assemblage.

For comparison, the species codes routinely reported by seafood dealers to the NMFS Northeast Region dealer database were examined. These reports are used to separate skate wing and bait landings for in-season monitoring of commercial quotas. Eight possible species codes may be reported for skate wing landings: one for each of the seven species in the complex, plus an "unclassified wings" code (NEFMC, 2010). The total weight of landings of each species was extrapolated by assigning the species composition proportions of the sampled landings to the total reported landings by the fishery. Aggregate skate wing landing weights were converted to whole weight equivalents using the accepted conversion factor of 2.27 (NEFMC, 2003). To determine if species relative abundance influenced the observed landings composition, these results were compared to skate biomass indices (3-year moving averages of stratified mean weight per tow) from the NMFS trawl survey (NMFS, 2011).

Results

Seafood Dealer Reporting

The most common species code reported by seafood dealers for skate wings was the "unclassified wings" code (69.9% of landings) (Fig. 3). This was followed by "winter skate" (29.2% of landings) and a small amount of "thorny skate" (0.4% of landings) (Fig. 3). All other species codes were rarely reported and collectively accounted for the remaining 0.5% of landings.

Port Sampling

During the study period (2005–12), a total of 92,833 skate wings were examined from 768 samples. A total of 91 samples were collected from GOM ports (13,743 wings), and 677 samples were collected from GB/SNE ports (79,090 wings), reflecting the relative volume of landings between the regions (Tables 1, 2). Three species were documented in the skate wing landings: winter, thorny, and barndoor

Table 1.—Species composition (%) of sampled landings and total skate wing landings in Gulf of Maine ports, 2005–12.

Year	Winter	Thorny	Barndoor	No. wings sampled	Total wing landings (t)
2005	61.88%	27.07%	11.05%	181	408
2006	49.96%	50.04%	0.00%	1,275	364
2007	94.15%	4.34%	1.51%	4,103	661
2008	99.32%	0.68%	0.00%	885	534
2009	97.10%	2.90%	0.00%	1,587	647
2010	95.36%	4.64%	0.00%	1,876	941
2011	100.00%	0.00%	0.00%	2,083	442
2012	100.00%	0.00%	0.00%	1,753	312

skates. The mean (±1 s.d.) individual wing weights were 0.80 ± 0.17 kg for winter skate, 1.16 ± 0.40 kg for thorny skate, and 0.99 ± 0.38 kg for barndoor skate. Winter skate wings were collected in every sample, and represented the dominant species across years and regions (98.5% of the total wings sampled). The remainder of sampled landings was comprised of thorny skate (1.4%) and barndoor skate (0.1%), both of which are prohibited species.

In GOM ports, winter skate comprised from 50.0 to 100.0% of the landings per year (mean = 87.2%) (Table 1). Reflecting its higher abundance in the GOM, thorny skate was the next largest component of GOM landings, ranging from 0.0 to 50.0% of the landings per year (mean = 11.2%) (Table 1). The percent occurrence of thorny skate in the sampled landings was considerably higher in 2005–06 (mean = 38.6%) than in 2007–12 (mean = 2.1%). The only other species collected in the GOM was barndoor skate, which represented 0.0–11.1% of landings per year (mean = 1.6%) (Table 1).

By contrast, landings in GB/SNE ports were completely dominated by winter skate (96.2–100.0% per year; mean = 99.1%) (Table 2). Thorny skate was found in 0.01–3.6% of landings per year (mean = 0.8%), and barndoor skate was found in 0.0–0.2% of landings per year (mean = 0.03%) (Table 2). The percent occurrence of thorny skate landings in this region also declined between the 2005–06 (3.1%) and 2007–12 (0.06%) periods. Despite a greater availability of barndoor skates adjacent to GB/SNE ports (Fig. 2b), very few barndoor skates were found in sampled landings in this region (Table 2).

Relative Abundance and Extrapolated Landings by Species

The relative abundance indices for winter, thorny, and barndoor skates from the 2005–12 NMFS trawl surveys are shown in Fig. 4a. Winter skate biomass far exceeded that of other species, with a mean (±1 s.d.) annual survey biomass of 6.00 (± 2.71) kg per tow. Winter skate continues to be above its target biomass of 5.66 kg per tow. Barndoor skate biomass averaged 1.07 ± 0.09 kg per tow, and thorny skate biomass averaged 0.36 ± 0.15 kg per tow over the study period. Barndoor skate biomass slightly increased during the study period and is nearing its regulatory biomass target of 1.57 kg per tow (Fig. 4a). Thorny skate biomass declined slightly (Fig. 4a), and this species remains well below its regulatory "overfished" biomass threshold of 2.06 kg per tow.

Table 2.—Species composition (%) of sampled landings and total skate wing landings in Georges Bank/Southern New England ports, 2005–12.

Year	Winter	Thorny	Barndoor	No. wings sampled	Total wing landings (t)
2005	96.20%	3.61%	0.19%	1606	7369
2006	97.41%	2.59%	0.00%	6482	8764
2007	99.80%	0.20%	0.00%	8537	10,124
2008	99.92%	0.08%	0.00%	10,473	9840
2009	99.97%	0.03%	0.00%	10,070	10,559
2010	99.94%	0.06%	0.00%	13,213	9195
2011	99.99%	0.01%	0.00%	13,714	6101
2012	99.91%	0.01%	0.08%	14,995	5939

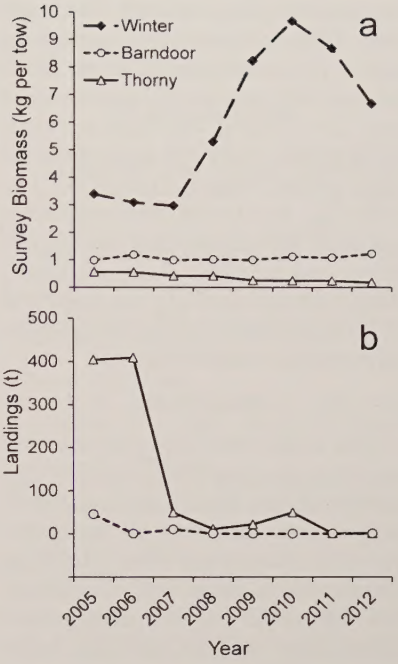


Figure 4.—Relative survey abundance of winter, barndoor, and thorny skates (a) and estimated commercial landings of barndoor and thorny (prohibited) skates (b) in the northeastern U.S. skate wing fishery, 2005–12. Relative survey abundance points represent the 3-year moving average stratified mean weight per tow from the NMFS Northeast Fisheries Science Center bottom trawl survey. Estimated landings values are based upon seafood dealer-reported total skate wing landings multiplied by the species composition proportions in Tables 1 and 2.

Annual skate wing landings (converted to whole weight) ranged from 7,777 t in 2005 to 11,206 t in 2009 (Tables 1, 2). The ports in the GB/SNE region accounted for the vast majority of coastwide landings, with GOM landings representing only 4.0–9.2% of the total (Table 1). The magnitude of landings of each species was extrapolated (Fig. 4b) when the species composition proportions from port sampling (Tables 1, 2) were applied to the total landings in each region. As expected, winter skates dominated the landings, averaging 8,911 ± 1,977 t per year. Thorny skate landings were much lower than winter skate but were still

comparatively high in 2005 (404 t) and 2006 (409 t), given their prohibited status. However, from 2007 to 2012, landings fell dramatically and averaged only 22 ± 22 t (Fig. 4b). Barndoor skate landings were very low throughout the study period, with a high of 45 t in 2005 (Fig. 4b). Survey biomass did not influence the proportional landings of thorny and barndoor skates, as thorny skate landings regularly exceeded that of barndoor skate despite having notably lower abundance (Fig. 4).

Discussion

This is the first study to use port sampling data to quantify species composition in this fishery, and our results suggest that sampling of the northeast U.S. skate wing fishery landings can provide a great deal of information that could improve management of the skate complex, including better species-specific monitoring, assessment, and regulatory compliance. This research effort provided new insights into the species composition of the skate wing fishery, estimated the magnitude of landings of each of the component species, and demonstrated high compliance with prohibited species regulations. It also highlighted the inadequacy of maintaining the "unclassified" reporting option for potentially monitoring species-specific skate landing trends.

Fishery-dependent sampling can be very useful in elasmobranch fisheries that are frequently considered to be data-poor. As there is ongoing concern regarding the exploitation of elasmobranchs around the world (Stevens et al., 2000; Dulvy et al., 2008; Ward-Paige et al., 2012; Dulvy et al., 2014), it is critical to improve our understanding of commercial fisheries that harvest them. Given the growing importance of skates and rays to global fishery catches relative to sharks, and their significant conservation concern (Dulvy et al., 2014), more research on these species groups is warranted to inform responsible conservation and management.

Port sampling and at-sea observers have proven very valuable to skate and ray fisheries management in several regions around the world (Machado et al., 2004; Wakeford et al., 2004; Stevenson and Lewis, 2010; Silva et al., 2012). For example, an experimental port sampling study used to characterize the species and size composition of skate and ray landings in Portugal found that landings were comprised of eight rajid species, but dominated by just blonde ray, *Raja brachyuran*, and thornback ray, *R. clavata* (Machado et al., 2004). Additionally, Silva et al. (2012) compared the species composition of skate landings reported by U.K. commercial vessels to the species composition estimated by at-sea observers. They found broad agreement between vessel and observer reports for the primary species landed (cuckoo ray, *Leucoraja naevus*; thornback ray, and blonde ray), but more variability in the contribution of 10 other less common species.

It is clear that monitoring species-specific landing trends in the skate fishery is intractable with an "unclassified" species reporting option for vessels and seafood dealers. Due to either a lack of confidence in species identification, or the lack of an incentive to attempt to identify the species, the vast majority of dealers used the "unclassified wings" code in their reports. However, the dominance of winter skates in the landings identified by port samplers should make it relatively simple for dealers to accurately report winter skate wing landings.

Not only are the other six managed skate species rarely, if ever, found in the landings, but the other species large enough for the wing market (thorny and barndoor) are prohibited species. Their wings are visually distinct from those of winter skate, and identifiable with minimal training (Collette and Klein-MacPhee, 2002). There are more than a dozen species of skates caught in U.K. fisheries in the eastern North Atlantic which were unclassified in landing reports for many years (Silva et al., 2012). However, as of 2008, all skate landings in this region were required to be reported by species, and fishery-dependent sampling demonstrated that species-level reporting by vessels was largely accurate for the dominant species (Silva et al., 2012).

In response to these concerns, in 2014 the NEFMC and NMFS implemented Framework Adjustment 2 to the Skate FMP, which permanently removed the "unclassified" species reporting option, and required species-specific reporting of skates by all vessels and dealers (NEFMC, 2014). A new skate species identification guide was developed and distributed by NMFS to support this transition.[4] It is anticipated that these regulatory changes will improve species-specific catch monitoring in the skate fisheries.

There are two reasonable hypotheses for the observed decline in the occurrence of prohibited thorny skates in the landings over the course of the study: 1) the availability of thorny skates to the fishery declined, and/or 2) compliance with the prohibited species regulations increased. Availability could decline either by changes in the spatial distribution or magnitude of fishing effort (i.e., to areas away from concentrations of thorny skates) and/or by declines in the relative abundance of thorny skates.

Overall fishing effort in the region's trawl and gillnet fisheries declined during the study period due to changing groundfish regulations (Brodziak et al., 2008), and some distributional shifts in fishing effort could have influenced the composition of skate landings. However, the relative abundance of thorny skate also declined during the study period, possibly affecting availability. Thorny skate trawl survey biomass steadily declined from 0.56 kg per tow in 2005 to 0.18 kg per tow in 2012, a decline of 68% (Fig. 4a). Given the comparatively high estimated landings of thorny skates prior to 2007 (Fig. 4b), as well as discard mortality in groundfish fisheries (Mandelman et al., 2013; NMFS[1]), this level of fishing mortality may have negatively impacted the population. However,

[4]ID guide is available online at: http://www.greateratlantic.fisheries.noaa.gov/stories/2014/skateidguide214.pdf.

more research is needed to investigate the causes of the thorny skate's decline off the northeastern United States, as overfishing is only one potential influence. Shifting distribution patterns and warming trends in the Gulf of Maine may also be playing a role in this species' availability to the NMFS trawl survey (Frisk et al., 2008; Nye et al., 2009).

Since the sharp decline in thorny skate landings was concurrent with the release of the prohibited species letter by NMFS in 2007, it appears that it may have had a significant effect in improving compliance. Prior to this outreach effort, fishing vessels and dealers may have been ignorant or dismissive of the prohibition on possession of thorny skates. Awareness and compliance with the prohibition on barndoor skate appears to be particularly high since their increased availability was not reflected in the landings composition. Due to the comparatively high profile of barndoor skate conservation concerns (Casey and Myers, 1998), including petitions to list them under the Endangered Species Act and their easily distinguishable morphological features, more fishermen were likely aware of the prohibition on barndoor skates than other species and discarded them when captured.

The estimated composition of skate landings appears to demonstrate high (>98%) compliance with the prohibited species regulations. Compliance with prohibited skate regulations in U.K. fisheries also appears to be high, with most prohibited species being discarded (Silva et al., 2012). If landings composition in the skate wing fishery simply reflected the species composition of the survey (i.e., the proportional abundance of winter, thorny, and barndoor skates), then prohibited species would likely be found in over 20% of the landings. Even though prohibited species landings are currently very low in the U.S. skate wing fishery, continued outreach and enforcement efforts are needed to maintain compliance, and allow these vulnerable stocks to rebuild.

It is possible that the 2005 and 2006 landing compositions more closely reflect skate landings composition prior to the implementation of skate fishery regulations in 2003. Since the species composition of skate wing landings was essentially unknown prior to the initiation of this study, data from 2005 and 2006 could be used as proxies to reconstruct historic landings composition. This information, coupled with long-term skate landings data and relative abundance information from the NMFS bottom trawl surveys, could improve species-specific catch time series used in stock assessments. Estimates of species- and gear-specific trends in discarding and discard mortality remain uncertain, but are also still needed to estimate total skate catch and fishing mortality (Mandelman et al., 2013; NMFS[2]). Some skate species appear to be more resilient to capture and discard in commercial trawl fisheries than others (Mandelman et al., 2013), further highlighting a need for more species-specific management (Hogan et al., 2013).

This improved characterization of landings in the skate wing fishery should help reduce scientific uncertainty and improve the likelihood of successful species-level stock assessments. Similar sampling efforts in the skate bait fishery would improve our understanding of the species composition distinct to that fishery and have similar benefits to management of the overall skate complex. In future years, if skate discard rates continue to decline, monitoring of landings composition will become even more valuable. It could also provide the logistical means to accurately monitor species-specific fishery quotas, and allow the fishery to move away from less efficient stock complex management.

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Meeting National Standard 8: Ground-truthing Social Indicators of Fishing in South Atlantic Coastal Communities

DAVID GRIFFITH, BRENT STOFFLE and MICHAEL JEPSON

National Standard 8 and South Atlantic Fisheries

Based on field research in 21 South Atlantic coastal communities reaching from Wanchese, N.C., to Palm Beach Shores, Fla., this article compares data from direct observations and interviews in the communities to data from publicly available sources such as fisheries statistics and the U.S. census, providing baseline information for social impact assessments, fisheries management plans, and other policy initiatives. The study emerged from ongoing attempts to meet the mandate of National Standard 8 (50 CFR Ch. VI (01 Oct 10 Edition: §600.345:60): "Conservation and management measures shall...take into account the importance of fishery resources to fishing communities by utilizing economic and social data that are based upon the best scientific information available..."

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ABSTRACT—National Standard 8 of the reauthorized Magnuson-Stevens Fisheries Management Act mandates that fisheries managers consider a community's dependence on fisheries when crafting regulations. This article compares findings regarding dependence on commercial and recreational fisheries from direct observations and interviews in 21 U.S. South Atlantic communities to findings from publicly available data sources such as the U.S. census. The comparisons revealed that, in over 80% of the 21 ports examined, data developed from direct observations and interviews and those developed from publicly available data sources yielded similar results. Where there were large discrepancies between the two sets of findings, in most cases, the ports were located in large metropolitan areas where fishing constituted a small proportion of the economy. These findings indicate that the use of publicly available data sources is an efficient way for fisheries managers and others to meet the mandate of National Standard 8 in a timely fashion, yet they also suggest that rapid ethnographic procedures can aid in characterizing fishing communities that differ in terms of size, rural vs. urban settings, gentrification, resilience, and other features that could assist fishery managers in evaluating the impacts of fishing regulations.

While concern for fishing communities is secondary to the concern for rebuilding and maintaining healthy fishery resources, National Standard 8 (NS8) nevertheless demands that social and economic data be developed to address questions such as a community's dependence on or engagement with fishery resources, its ability for sustained participation in fisheries, and whether or not a Fishery Management Plan or policy initiative will adversely affect the community.

National Standard 8 defines a fishing community as "a community that is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew, and fish processors that are based in such communities. A fishing community is a social or economic group whose members reside in a specific location and share a common dependency on commercial, recreational, or subsistence fishing or on directly related fisheries-dependent services and industries (for example, boatyards, ice suppliers, tackle shops)" (50 CFR Ch. VI (1 Oct 10 Edition: §600.345:61).

The 21 fishing communities we profiled range from small, unincorporated communities like Wanchese and Sneads Ferry, N.C., to large metropolitan areas like Wilmington, N.C., Charleston, S.C., Savannah, Ga., or the heavily populated strip of south Florida coast around Palm Beach Shores. In addition to those just mentioned, the others were: Hatteras Village, Beaufort, Morehead City, Atlantic Beach, and Wrightsville Beach in North Carolina; Little River and Murrells Inlet in South Carolina; Brunswick, St. Simons Island, and St. Marys in Georgia; and Fernandina Beach, St. Augustine, Cape Canaveral, Sebastian, Ft. Pierce, and Palm Beach Shores in Florida (Fig. 1).

Methods

This research, conducted from August 2012 to June 2013, combined direct observations and interviews with the collection of secondary source data collection in the 21 ports. In each port, we visited fishing centers, fish packing facilities (commonly known as fish houses), recreational and commercial marinas, docks, fishing regulatory offices, seafood retail markets and restaurants, marine- or water-oriented museums, and other sites related to commercial and recreational fishing. At these sites we observed activities, took photographs, interviewed people both casually and in more depth about local recreational and commercial fishing, and completed inventories of marine-related businesses. We conducted web-based searches about each community, collecting data on fishing

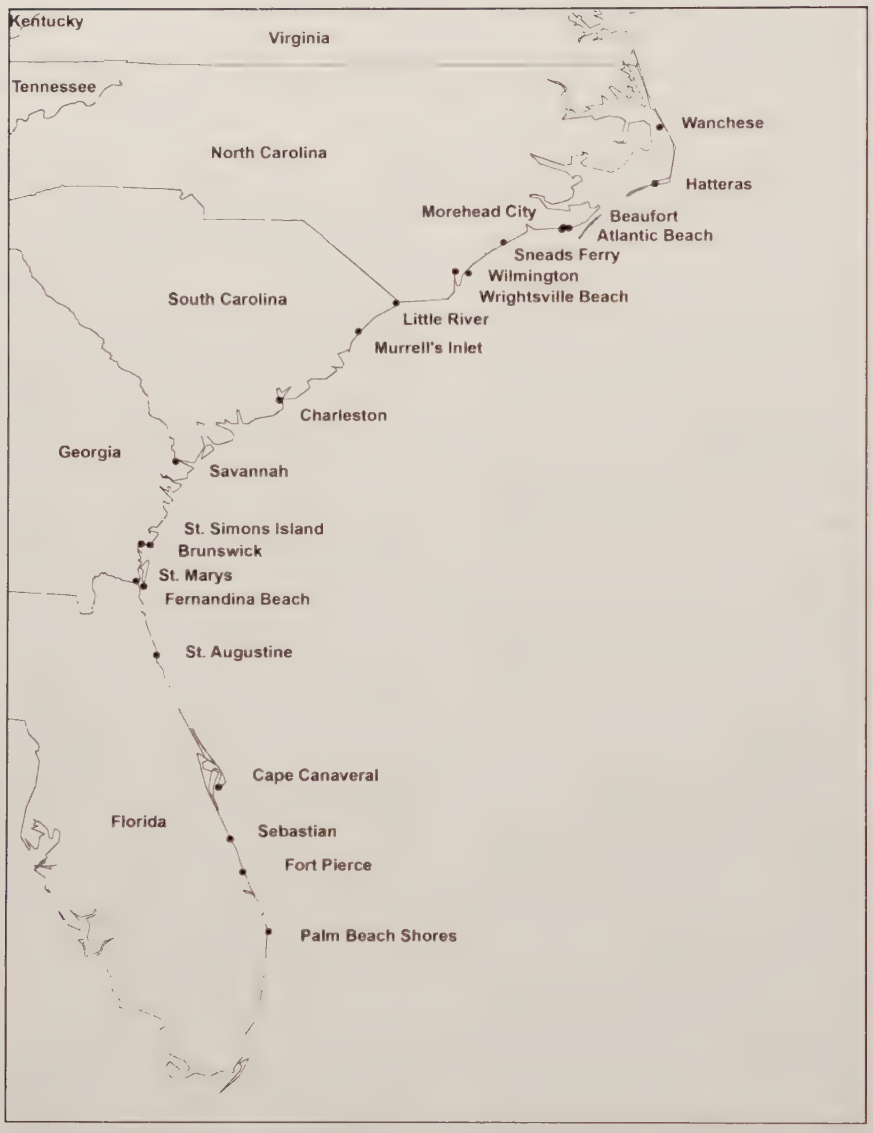

Figure 1.—U.S. South Atlantic communities in the study.

and seafood related businesses, demographics, and other public data. Finally, we collected or perused published and printed materials from local bookstores, archives, local libraries, and other repositories (Earll, 1887; Ballance, 1989; Cecelski, 2000; Beal and Prioli, 2002; Garrity-Blake and Nash, 2012).

Interview Protocol

Based on these activities, we developed an informal interview protocol and interviewed up to 15 individuals per port, completing a total of 345 usable interviews with a range of individuals knowledgeable about a variety of topics related to their communities. Informants included commercial and recreational fishermen (including charter boat captains and mates), local realtors, seafood workers, local politicians, librarians, school teachers, and residents from a variety of other occupations. In all, those we interviewed spanned 63 occupations.

Interviewees in each community were not explicitly randomly sampled; they were selected because of their long-time knowledge of the community or direct involvement in recreational or commercial fisheries. However, in most cases, individuals were intercepted at fishing sites, lending some randomness to the sampling process. Interviewers were instructed to probe individuals about their knowledge of local fishing, or they selected people referred to them as people particularly knowledgeable about local fishing. These interviews were then post-coded for the qualitative and quantitative discussions below.[1]

Post-coding is a time-consuming process of teasing from the texts of the interviews similar information for comparative purposes. The result of this process is that percentage counts are presented for many variables and, in some cases, new variables are constructed from a number of comments made by those interviewed. For example, we asked the general question of how people characterized their community, which resulted in over 80 descriptors; of these we developed a "gentrification" variable that included descriptors such as "wealthy," "high cost of living," "high taxes," and so forth.

Informant Characteristics

The following series of tables presents information on the sample from all 21 ports.[2] Table 1 includes demographic characteristics about the

[1]In the social sciences, this is referred to as a judgment sample: a sample of individuals who represent a domain of knowledge (Babbie, 2010; Bernard, 2011). While they cannot be said to represent, statistically, the community in the same way a census or a random sample might, they can give us sound information about the trajectories of each community's fisheries data that, replicated across communities, can be compared to other community fisheries visited in the study. Sampling procedures of this kind are widely used in the cognitive social sciences, guided by a general logic that people most qualified to provide information about a specific domain, such as community fisheries, are those who are actively involved with that domain. A random sample even in a small community like Wanchese might well include residents who know little to nothing about fishing.

[2]This article is based on research conducted with the National Marine Fisheries Service. A two-volume report was produced under this contract: "Ground-truthing social indicators of fishing in North Carolina, South Carolina, Georgia, and east Florida fishing communities: volume I (comparing remote and direct observations) and

Table 1.—Selected output from all interviews (n=345).

Variable	Output
Gender	Males = 68%, Women = 32%
Age	Mean = 51.75 (sd=13.53) Range = 20–81
Years employed	Mean = 18.36 (sd=16.75) Range = 1–77
Has seen change in the community	Yes = 95% No=5%
Would advise a young person to move to this community?	Unqualified yes = 45.4%; No = 19.4%; Qualified yes = 35.2%[1]
Average score for "There is a strong community here."[2]	8.27 (sd=1.67)
Average score for "There is a strong commercial fishing community here."	5.57 (sd=3.15)
Average score for "There is a strong recreational fishing community here."	7.79 (sd=2.38)
Average score for "Community depends on fishing economically."	5.51 (sd=2.92)
Average score for the strength of the community's overall economic health.	6.16 (sd=2.29)
Average score for the strength of the community's commercial fisheries' economic health.	3.66 (sd=2.25)
Average score for the strength of the community's recreational fisheries' economic health.	5.70 (sd=2.65)

[1]For example, yes if the person had enough money.
[2]Figures are for NC, SC, and GA ports only.

interview respondents, as well as information on the health of the communities and their commercial and recreational fisheries. Each of the last six variables was based on a scale from 1 to 10, with 10 indicating very strong and 1 indicating very weak. We discuss these findings in more detail below.

Data in Table 1 confirm what many observers of commercial fisheries and many members of commercial fishing families perceive: that commercial fishing communities and their economic health are not as strong or healthy as are recreational fishing communities. They also suggest the people interviewed believe that the coastal communities of North Carolina, South Carolina, and Georgia—most of which are communities with a lengthy history of fishing—have strong senses of community in general; the average "community strength" score of 8.27 and a standard deviation of 1.6 indicates little variability. Indeed, the ways in which people talk about their communities suggest that they feel strong ties to them. This is also reflected in the fact that over 80% of those interviewed said that they would advise a young person to move to their community.

Comparative Analysis

In essence, this work directly compares data from publicly available sources to data from direct, on-the-ground field research to determine how accurately the publicly available source data compares in terms of developing social indicators that estimate six community features: 1) dependence on and engagement with commercial fishing, 2) dependence on and engagement with recreational fishing, 3) sustainability, 4) vulnerability, 5) resilience, and 6) gentrification. Specifically, we draw primarily on Jepson and Colburn (2013) and secondarily on Jacob et al. (2013; Jacob et al.[3]) for estimates from remote data sources.

Dependence on and Engagement with Commercial and Recreational Fishing

During both the open-ended interviewing phase of the research and the more guided interviews, we asked several pointed questions about communities' relationships with commercial and recreational fishing. These included the five questions asking community residents to rank the strength or health of their fishing community and fishing economy on a scale of 1 to 10, including the general statement that "This community depends on fishing economically." Second, we asked two open-ended questions on the principal threats facing recreational fishing and commercial fishing.

Table 2 draws on the ground-truthing data—or those data from direct observations and interviews in the 21 communities. Because the sample was not completely randomly selected, in addition to reporting means and standard deviations, we also performed chi-square tests that compared the ports by their economic dependence on fishing and found that the differences were statistically significant (x^2=47.402; df=20; p=0.001). The column entitled Mean is an average of the scores from the five previous columns, or, in other words, an index that incorporates all those data. We are not arguing that each item in the index should be given equal weight, only that each should be included in the index. We provide the data for each item in the index for the reader to make his or her own judgement about each item's relative weight.

Table 3 compares the ground-truthing data with data from publicly available sources developed by Jepson and Colburn (2013) and others in their work to meet the criteria of National Standard 8 in their preparation of fishery management plans and social impact assessments. Among other things, the new ranks show that a community highly economically dependent on commercial fishing, such as Hatteras Village, may be less highly ranked when both commercial and recreational fishing data are considered together. According to these data, Wanchese, N.C., emerges as the community most attached to fishing, with other important fishing locations being Charleston

volume II (community profiles). Report available from the Southeast Regional Office.

[3]Jacob, S., M. Jepson, C. Pomeroy, D. Mulkey, C. Adams, and S. Smith. 2002. Identifying fishing-dependent communities: development and confirmation of a protocol. (MARFIN) Rep. prep. for the NMFS Southeast Reg. Off. By Univ. Fla. Dep. Family, Youth, Community Serv., Gainesville, Fla., 214 p.

Table 2.—Fishing dependence and engagement by port, interview data.

Port	Dependence on fishing economically [Rank]	Commercial fishing community strength	Recreational fishing community strength	Commercial fishing economic health	Recreational fishing economic health	Mean	New Rank[1]
Wanchese	8.29 [1]	8.71	8.57	4.71	6.00	7.26	1
Hatteras Village	7.93 [2]	7.53	8.07	4.00	5.80	6.67	5
Beaufort	6.81 [3]	6.37	8.50	4.44	7.31	6.69	4
Morehead City	6.00 [6]	5.64	8.50	4.14	6.07	6.22	6
Atlantic Beach	5.13 [12]	4.00	7.00	3.73	5.87	5.15	16
Sneads Ferry	6.00 [6]	8.15	7.62	5.08	6.77	6.72	3
Wrightsville	3.33 [19]	2.40	6.53	2.60	5.67	4.11	21
Wilmington	5.67 [10]	5.40	7.27	4.60	6.07	5.80	9
Little River	6.40 [4]	6.40	7.33	3.33	4.27	5.55	12
Murrells Inlet	6.27 [5]	7.80	7.67	3.13	4.87	5.95	7
Charleston	6.00 [6]	6.87	8.60	5.27	6.93	6.73	2
Savannah	4.87 [13]	6.20	8.40	3.67	5.60	5.75	11
Brunswick	3.87 [17]	4.47	6.53	3.00	4.20	4.41	20
St. Simons	4.80 [15]	5.73	7.87	3.40	5.33	5.43	13
St. Marys	2.87 [20]	3.27	8.67	2.73	6.20	4.75	19
Fernandina	4.82 [14]	3.94	6.41	3.82	5.35	4.87	18
St. Augustine	5.24 [11]	4.57	7.62	2.81	5.29	5.11	17
Cape Canaveral	4.00 [16]	5.40	7.30	3.70	5.65	5.21	15
Sebastian	5.95 [7]	4.85	7.90	2.90	4.85	5.23	14
Ft. Pierce	5.87 [9]	5.54	8.29	3.25	6.00	5.79	10
Palm Beach	5.91 [8]	5.27	8.59	3.55	5.86	5.84	8
Totals	5.51	5.57	7.79	3.66	5.70	5.65	

[1]Rank based on the average of the five scores.

Table 3.—Fishing dependence and engagement by port, publicly available data.

Port	Dependence on fishing economically [Rank]	Commercial fishing reliance [Rank]	Recreational fishing reliance	Commercial fishing engaged	Recreational fishing engaged	Average Rank[1]
Wanchese	8.29 [1]	4.020 [1]	0.785	2.117	0.964	5
Hatteras2	n.d.	n.d.	n.d.	n.d.	n.d.	n.a.
Beaufort	6.81 [3]	1.109 [3]	2.511	2.419	2.133	8
Morehead City	6.00 [6]	-0.013 [9]	2.447	1.040	2.959	7
Atlantic Beach	5.13 [12]	0.300 [4]	4.476	0.265	4.155	7
Sneads Ferry	6.00 [6]	2.565 [2]	0.478	2.137	0.409	8
Wrightsville	3.33 [18]	-0.173 [14]	1.520	-0.061	1.472	9
Wilmington	5.67 [10]	-0.206 [16]	1.521	3.215	1.284	10
Little River	6.40 [4]	-0.077 [10]	0.226	0.375	0.489	8
Murrells Inlet	6.27 [5]	0.103 [6]	1.479	0.685	1.662	6
Charleston	6.00 [6]	-0.222 [15]	0.163	1.716	0.265	12
Savannah	4.87 [13]	-0.251 [20]	2.534	-0.045	3.515	14
Brunswick	3.87 [17]	0.004 [8]	2.749	1.313	2.368	12
St. Simons	4.80 [15]	-0.251 [19]	1.803	0.058	1.679	18
St. Marys	2.87 [19]	-0.224 [17]	1.372	0.381	1.206	19
Fernandina	4.82 [14]	-0.086 [11]	4.499	0.572	4.414	12
St. Augustine	5.24 [11]	0.084 [7]	7.153	1.769	7.013	8
Cape Canaveral	4.00 [16]	-0.137 [13]	2.892	0.455	3.380	13
Sebastian	5.95 [7]	-0.225 [18]	1.334	0.293	-0.284	9
Ft. Pierce	5.87 [9]	0.120 [5]	7.203	1.012	6.716	9
Palm Beach	5.91 [8]	-0.095 [12]	1.454	-0.099	1.160	13

[1]Measure developed based on remote data, combining recreational and commercial data.
[2]No remote data were collected for Hatteras Village, which ranked #2 based on the ground-truthing data.

(ranks 6 and 2), Sneads Ferry (ranks 6 and 3), Beaufort (ranks 3 and 4), and Hatteras Village (ranks 2 and 5).

Table 3 lists the above communities in terms of four indices of reliance and engagement, developed primarily by Michael Jepson, Steve Jacob, and a few other social scientists.[4] They are

1) The "Commercial Fishing Reliance Index," which includes the value of fish landings by population, number of commercial permits by population, number of dealers with landings by population, and percentage of population employed in agriculture, forestry, and fishing. Scores are either negative or positive based on whether or not they are less than or more than one standard deviation from the mean.
2) The "Recreational Fishing Reliance Index," which includes recreational charter boat fishing by population, private recreational fishing by population, and shore recreational fishing by population.
3) The "Commercial Fishing Engagement Index," which includes the total value of landings, total commercial permits, total number of dealers with landings, and the pounds of landings—all without reference to the size of the population.
4) The "Recreational Fishing Engagement Index," which includes recreational charter boat fishing pressure (i.e., fishing trips), private recreational fishing pressure, and shore recreational fishing pressure—again without reference to the size of the community's population.

These figures are simple to interpret: the higher the score, the more reliant or engaged the community is in commercial or recreational fishing. While indices are susceptible to fault at any point in their construction, they are helpful in attempts to measure complex phenomena that cannot be reduced to mere counts or modeling exercises. Due to the problems with indices, however, another way to consider these data is to group the ports with rankings close to one another, as we have done in Table 4.

Again, in Table 4 we see considerable overlap between the two rankings, yet the differences deserve explanation. Of the 21 ports the two ranking methods clearly show Wanchese as the most dependent (or reliant) on commercial fishing; they draw out other similarities as well. Beaufort ranks three in both lists, and the North Carolina communities north of Wrightsville Beach—all except Snead's Ferry in and around the Albemarle-Pamlico Estuarine System—rank in the top ten. The two ranking methods also derived similar ranks for Murrells Inlet, St. Marys, and Cape Canaveral.

[4]These indices were developed at a small conference held in 2008 at the Houston Area Research Center, organized by Steve Jacob (York College, York, Penn.), and Pricilla Weeks (Houston Area Research Council, Houston, Tex.), which the authors attended.

Only four or five places separated Snead's Ferry, Wrightsville Beach, St. Simons, St. Augustine, Fernandina, Ft. Pierce, and Palm Beach. By contrast, larger discrepancies between the remote data source and ground-truthing data were found with regard to Atlantic Beach (group 3 in the ground-truthing rankings, 1 in the remote), Wilmington (group 2 in the ground-truthing data, 4 in the remote), Charleston (high in group 2 in the ground-truthing rankings, low in group 3 in the remote), and Sebastian (group 2 in the ground-truthing, 4 in the remote).

While we found large discrepancies between the ground-truthing and remote data in 4 (19%) of 21 ports, 2 of them can be explained, in part, by their size. Remember that the commercial fishing resilience index is based largely on variables relative to population size. The three most heavily populated ports in the sample are Wilmington, Charleston, and Savannah—each of which contains over 200,000 residents, in the midst of which live relatively few fishing families.

In all three ports, the ground-truthing data collection targeted areas within the three metropolitan centers, where we learned substantial fishing activity took place (e.g. marinas, piers, around fish houses, at charter boat docks, etc.), and where local residents were more likely to view fishing as a key part of their local economy—even if not a major element in the larger metropolitan area. In Wilmington, for example, early on in the research we were steered toward Carolina Beach, a community that is part of the Wilmington metropolitan area yet known for its fishing charters. In this area of Wilmington, with at least ten fishing charters and a large head boat, fishing is clearly important, which accounts for Wilmington's higher rank in the ground-truthing data.

The rankings of fishing communities show the overall importance of fishing in North Carolina in particular, with five of the eight communities listed falling into the top six ranks. By contrast, none of Georgia's communities ranked highly, and Florida's and South Carolina's were mixed. The importance of fishing to North Carolina is understandable in light of its complex coastline, particularly the Albemarle-Pamlico Estuary (Fig. 2), which includes three sounds rich in blue crabs, *Callinectus sapidus*; mullet, *Mugil cephalus*; Atlantic croaker, *Micropangonias undulates*; spot, *Leiostomus xanthrus*; and other estuarine resources, the Outer Banks with their proximity to the Gulf Stream, and several inlets and ferry channels facilitating marine navigation.

Table 4.—Ports grouped by quartiles from most to least dependent on fishing.

Groups of Ports	Ground-Truthing Rank	Remote Rank
Group 1: Most Dependent	Wanchese	Wanchese
	Hatteras Village	Beaufort
	Beaufort	Atlantic Beach
	Little River	Snead's Ferry
	Murrells Inlet	Ft. Pierce
Group 2: 2nd Most Dependent	Morehead City/ Charleston/ Snead's Ferry[1]	Murrells Inlet
	Sebastian	St. Augustine
	Palm Beach	Brunswick
	Ft. Pierce	Morehead City
	Wilmington	Little River
Group 3: 3rd Most Dependent	St. Augustine	Fernandina
	Atlantic Beach	Palm Beach
	Savannah	Cape Canaveral
	Fernandina	Wrightsville Beach
	St. Simons	Charleston
Group 4: Least Dependent	Cape Canaveral	Wilmington
	Brunswick	St. Marys
	Wrightsville Beach	Sebastian
	St. Marys	St. Simons
		Savannah

[1]All three communities had the same rank.

Yet even in North Carolina, commercial fishing is in decline. The number of Standard Commercial Fishing Licenses (SCFL's) has fallen by around 1,000 over the past decade, from 6,632 in 2002 to 5,640 in 2012 (NCDMF, 2013). By contrast, recreational fishing licenses from 2007 to 2011 remained more or less stable, fluctuating from a low of over 411,000 to a high of nearly 470,000 (NCDMF, 2013). Charter Boat licenses also remained fairly stable from 2008, when 653 were issued, to 2011, when 650 were issued, although the number fell to 576 in 2012 (NCDMF, 2013).

Sustainability, Vulnerability, and Resilience

Sustainability is a concept that has received a great deal of attention in the scientific literature recently, spawning a National Science Foundation initiative known as Science, Education, and Engineering for Sustainability (www.nsf/sees/). That involved a wide variety of disciplines—from engineering and biology to economics and anthropology—and occupied people interested in a range of activities, from the conservation of natural resources to the development of products with longer lives and less problematic disposal profiles. While this has led to a number of different interpretations of what constitutes sustainability, in terms of fisheries and fishing communities, sustainability generally means the ability to maintain and reproduce fishing livelihoods and fishing activities without jeopardizing fishery resources.

Pauly et al. (2002), for example, described a sustainable fishery as one where "fish populations were naturally protected by having a large part of their distribution outside of the range of fishing operations." In the cases they discussed, this occurred where fish populations were exploited by small numbers of fishermen located in extreme climates, (e.g., the Arctic), or were "protected" because intervening factors, such as warfare, made the seas unsafe for fishing. Regulations on fishing, usually based on fisheries biology, have been developed to achieve

Figure 2.—Albemarle-Pamlico Estuarine System.

maximum sustainable yields—in other words, to achieve sustainability in fisheries. Among the more popular current measures to protect fish stocks are habitat-based management alternatives such as Marine Protected Areas and measures to protect nursery grounds and other environments conducive to fish stock health.

In terms of fishing communities, sustainability involves more than protecting fish, however many fish stocks are critical to a fishing community maintaining its identity and its heritage. Sustaining fishing livelihoods involves continued access to dock space, market infrastructure such as fish houses, and the ability to target species that can bring ex-vessel prices high enough to cover expenses and remunerate labor.

The focus on sustainability is often coupled with a consideration of what makes resources or communities vulnerable to threats to sustainability or resilient against such threats (Cutter et al., 2003). Thus, in relation to sustainability, vulnerability and resilience are opposites, and the three concepts are most effectively discussed together. In this research, we asked people in each port what factors threatened their communities. We listed above what they considered the principal threats to commercial and recreational fisheries, but we also asked them what factors would make their communities vulnerable to decline.

Table 5.—Vulnerability type.

Type of Vulnerability	Percent
Loss of Use	44.5
Development Problems	20.0
Economic Issues	35.5

From this, we identified several factors that, according to residents, increased their community's vulnerability. Across all 345 interviews, we elicited 38 sources of vulnerability, including fishing regulations, fuel prices, pollution, rampant development, and the loss of various kinds of infrastructure (e.g. fishing piers) or natural resources (e.g., water channels due to lack of dredging). Once we had this list, we grouped them by more general principles into three groups: 1) Loss of Use (e.g., closing fishing piers, reduced dredging, more regulations on fishing, a reduction in activities for tourists, beach erosion, etc.); 2) Development Problems (e.g., growth not sustainable, too many tourists, new people moving in, old residents leaving, etc.); and 3) Economic Issues (e.g., increased fuel prices, job losses, higher taxes, etc.) (Table 5). Overall, Loss of Use was perceived as the most common source of vulnerability, followed by economic issues, and finally development problems.

Based on these groups, we ran frequency counts on a port-by-port basis to determine how each community was liable to be influenced by each category of vulnerability. We also attempted to see how different sources of vulnerability were associated with significant changes taking place in the communities and how vulnerability was related to fishing dependence.

Table 6 shows how these types of vulnerability are distributed across ports, and these data give some indication of the absolute vulnerability of

Table 6.—Vulnerability by port. Numbers in parentheses refer to sources of vulnerability.

Port (N sources)	Loss of Use	Development	Economics
Wanchese (19)	74%	0%	26%
Hatteras (31)[1]	45%	19%	36%
Beaufort (25)	48%	16%	36%
Morehead (13)	23%	31%	46%
Atlantic (24)	46%	12%	42%
Sneads Ferry (20)	30%	30%	40%
Wrightsville (28)	32%	14%	54%
Wilmington (26)	58%	19%	23%
Little River (23)	48%	13%	39%
Murrels Inlet (18)	61%	11%	28%
Charleston (18)	28%	28%	44%
Savannah (11)	36%	54%	10%
Brunswick (21)	33%	29%	38%
St. Simon (18)	50%	50%	0%
St. Mary (13)	15%	30%	55%
Fernandina (25)	40%	16%	44%
St. Augustine (33)	42%	6%	52%
Cape Canaveral (29)	48%	10%	42%
Sebastian (27)	55%	15%	30%
Ft. Pierce (31)	48%	13%	39%
Palm Beach (34)	38%	35%	27%

[1]Boldface type indicates those communities having 25 or more sources of vulnerability.

Table 7.—Vulnerability by dependence on fishing.

Vulnerability type/ fishing dependence	Low fishing dependence	High fishing dependence
Loss of use	38%	51%
Development	24%	16%
Economic issues	38%	33%

Chi-square = 6.314; df=2; p=0.043

the fishing communities in our sample, in that the higher numbers of sources indicate increased vulnerability, as well as the types of vulnerability likely to threaten each community. The data indicate that ten communities (noted in bold in Table 6) have 25 or more sources of vulnerability, including Hatteras Village, Beaufort, Wrightsville Beach, Wilmington, Cape Canaveral, St. Augustine, Sebastian, Fernandina, Ft. Pierce, and Palm Beach. None of the South Carolina or Georgia communities were in this group, while all of the Florida communities were in this group.

In addition to presenting the raw data on types of vulnerability each community experiences, we grouped communities by high and low fishing dependence (above 5.95 on the dependence scale = high; below 5.95 = low) and ran cross-tabulations on vulnerability type. This showed that communities that were highly dependent on fishing were significantly more likely to be vulnerable to "loss of use" sources of vulnerability than communities less dependent on fishing (Table 7). This may be, in part, because the "loss of use" category included increased regulations on fishing activities, which usually translates into reduced use of fisheries stocks or other natural resources. By contrast, residents in low fishing dependence communities believe them to be more vulnerable to development pressures than those in high fishing dependence communities, perhaps because gentrification has advanced further in those communities already.

One final measure of vulnerability comes from the information on how the communities have changed in the past 5–10 years. As noted, all the communities we studied had experienced changes in this time period, and the types of changes mentioned coincided with many of the developments that residents associated with vulnerability. Overall, the most common changes noted were population growth (cited by 38% of those interviewed), economic decline (14%), less fishing due to increased fishing regulations (13%), and more of a focus on tourism and retirees (11%).

To create a measure of vulnerability from these data, we grouped responses into one of two categories: negative for commercial fishing (e.g., loss of working waterfront) and positive for commercial fishing (e.g., increased demand for local seafood). After running frequency counts on the responses, we grouped them into either negative for recreational fishing (e.g., loss of a fishing pier) or positive for recreational fishing (e.g., increase in charter boats). The results of these statistical exercises are given in Table 8.

In line with other findings presented above, these figures clearly demonstrate that sources of vulnerability to commercial fisheries are far more common than sources of vulnerability to recreational fisheries. In every port, changes that have been positive to commercial fishing are far smaller than those that have been negative. By contrast, in several ports, developments that have been positive to recreational fishing outweigh those that have been negative. The cross-tabulation in Table 9 shows that significantly more positive than negative changes in the ports in our study have affected recreational fishing than have affected commercial fishing, with 93% of the changes negatively affecting commercial fishing, compared to 42% of the changes negatively affecting recreational fishing. Negative changes affect both, however, in 41% of the cases, while only 6% are positive for both.

In the face of such vulnerability, what can we say about community resilience and sustainability? Again, to examine how resilient fishing communities may be, we turned to the list of community characteristics to develop

Table 8.—Vulnerability by port.[1]

	Commercial Vulnerability		Recreational Vulnerability	
Port	Neg	Pos	Neg	Pos
Wanchese	14	0	9	5
Hatteras	13	1	7	7
Beaufort	13	3	3	13
Morehead	12	2	3	11
Atlantic	14	0	8	6
Sneads Ferry	13	0	2	11
Wrightsville	12	3	7	8
Wilmington	10	5	4	11
Little River	12	2	10	4
Murrels Inlet	15	0	6	9
Charleston	14	0	3	11
Savannah	13	2	4	11
Brunswick	13	1	6	8
St. Simon	13	0	1	12
St. Mary	19	1	7	7
Cape Canaveral	19	1	12	8
St. Augustine	19	1	10	10
Sebastian	18	1	7	12
Fernandina	15	1	5	11
Ft. Pierce	20	1	14	7
Palm Beach	21	0	11	10

[1]Numbers refer to sources of vulnerability.

Table 9.—The quality of changes in the community for commercial and recreational fishing.

Quality of change	Positive for recreational	Negative for recreational	Totals
Positive for commercial	20 (6%)	5 (1%)	25 (7%)
Negative for commercial	172 (52%)	134 (41%)	306 (93%)
Totals	192 (58%)	139 (42%)	331 (100%)

Chi-square = 5.370, df =1, p=0.02

an index of resilience, presented in Table 10, assuming that in those communities that residents describe with terms such as "close-knit," "hardworking," "family-oriented," and other similar terms will be more resilient than those that tend not to be so described. The characteristics we selected for this index are generally those associated with strong inventories of social capital—or the social networks and memberships in community institutions that allow people to marshal their resources toward solving challenges to their communities (Griffith, 1999; West and Garrity-Blake, 2003; Griffith et al., 2007). Because of the importance of group membership in the formation and deployment of social capital, and the importance of identity in group membership, we also included in this index characteristics such as "religious," "unique language," and "rural."

Based on the data in Table 10, the most resilient communities tend to be smaller and more rural than those that are less resilient, although not in all cases. While the communities of Charleston and Savannah are the least resilient, according to this measure, Wilmington's resilience score is relatively high. On the one hand, this finding calls into question a measure of resilience based on social capital characteristics, in that the larger communities may be more resilient generally to things such as weather events, economic decline, etc. because they have more diversified economies, more resources, more people, and so forth to deal with such challenges.

On the other hand, we may consider this measure as indicative of the resilience of fishing communities rather than communities in general. Larger communities such as Charleston and Savannah may be able to withstand the loss of commercial fishing and even recreational fishing exactly because they are large, diversified economies. This may also explain why the Sneads Ferry's fishing community is considered not very resilient by this measure, in that the presence of nearby Camp Lejeune (a U.S. Marine Corps base) may be enough to absorb most of those displaced from fishing.

The loss of fishing to places like Wanchese, Hatteras Village, and even St. Marys, by contrast, could deliver a devastating blow to their local economies, proportionately far more damaging than the loss of fishing from large economic centers. Because of this, residents in these ports may be more likely to view themselves as the kind of people who "hunker down" in the face of a challenge and come together as a community to deal with it.

This is, in fact, exactly what happened in Wanchese and Hatteras Village in the wake of two major storm events, Hurricane Irene and Superstorm Sandy. Although these events flooded the communities and damaged homes, instead of abandoning the communities their residents repaired, raised their houses, and stayed. Further, the residents of Wanchese have united around the issue of the dredging of Oregon Inlet—a U.S. Army Corps of Engineers' activity that is essential to allowing large vessels access to Wanchese fish houses (Davis, 2012).

It may also be the case, however, that the items we selected for the index were more commonly mentioned by those living in smaller communities, and hence the index is biased toward finding smaller communities more resilient. Yet having participated in the interviews in both large and small ports, we did not find that descriptors such as "close-knit" were confined to smaller communities; this may be due to people's ideas of community as being more narrowly conceived there than a metropolitan area.

Considering the above data on vulnerability and reliability, the sustainability of fishing in these ports is highly variable. Overall, currently, the data suggest that recreational fisheries are less vulnerable than commercial fisheries to loss of use or development, but this does not automatically mean that recreational fisheries are more sustainable than commercial fisheries in the long term. Recreational fisheries—particularly charter and head boats—are particularly sensitive to changes in tourist economies, fuel prices, and access to fish stocks, making them more highly vulnerable to reduced discretionary spending among consumers.

Many of these ports, particularly in Florida and South Carolina, have invested heavily in promoting tourism and related service-oriented economic sectors—sectors rarely lauded for producing high-income jobs and discretionary income—and whether or not growth of this nature is sustainable is a question that goes well beyond the question of whether or not recreational fisheries are. Recreational fisheries that are tied to such development models may not be any more sustainable than the development models themselves.

Regarding the sustainability of commercial fisheries, one of the reasons that communities like Wanchese and Hatteras Village may have scored highly on the resilience index is that they are both bringing a number of people together to promote community-based fisheries, although based on slightly different models. Wanchese,

Table 10.—Resilience by port.

Port	Resilience score	Rank
Wanchese	21	1
Hatteras	18	3
Beaufort	12	9
Morehead City	10	10
Atlantic Beach	17	4
Sneads Ferry	13	8
Wrightsville	13	8
Wilmington	17	4
Little River	13	8
Murrells Inlet	10	10
Charleston	8	12
Savannah	4	13
Brunswick	9	11
St. Simons	12	9
St. Marys	20	2
Fernandina	9	11
St. Augustine	14	7
Cape Canaveral	21	1
Sebastian	16	5
Ft. Pierce	13	8
Palm Beach	15	6
Average	13.6	

the more traditional model of the large fish house organizing fleets, and Hatteras Village, the somewhat newer model of promoting somewhat more independent, small-scale fisheries developing local markets for seafood.

Across North Carolina, these efforts have been supplemented by the development of local catch groups (Outer Banks Catch, Ocracoke Fresh, Carteret Catch, Brunswick Catch, and NC Catch[5]) that promote local seafood in local restaurants by creating connections between consumers and commercial fishing families. Whether fish-house organized or more independent, both types of fisheries are firmly embedded in the identities and cultural heritage of their respective communities. Because of this, they are more likely to recruit new members to their fisheries and are more likely to nimbly adapt to regulatory, physical, and natural environments.

Already some fish houses in Wanchese, for example, have scaled back the sizes of their vessels due to the problems of keeping Oregon Inlet open, giving them access to a number of in-shore, near-shore, and off-shore fishing grounds. It is perhaps because of these kinds of adaptations that Jepson and Colburn (2013:15) did not find Wanchese to be particularly highly socially vulnerable.

Gentrification

Along with imported seafood, the expansion of fishing regulations, and rising fuel costs, gentrification—or economic development oriented toward wealthier residents—ranks high among threats to commercial fishing today (Colburn and Jepson, 2012). As noted earlier, gentrification usually results in rising property and rental values, higher taxes, increased insurance costs with more expensive risk pools, and decreased access to fishery resources as marinas change from commercial to leisure uses and slip space cost rises. Additional problems arising from gentrification for commercial fishing can be pressures to change the aesthetics of coastal landscapes away from working waterfronts and toward boardwalks, shops, restaurants, etc., resulting in the loss of marine support businesses (e.g., marine railways), fish houses, fueling docks, etc. Finally, gentrification can lead to crowding on waterways, organized attempts by private and public interests to curtail fishing activities when they interfere with recreational activities, and other user-based conflicts.

Gentrification has become a major problem for commercial fisheries in the South Atlantic region, with the region's mild climates and attractive local natural resources attracting many people who have little to no appreciation of the heritage value of working waterfronts or commercial fisheries (Colburn and Jepson, 2012). While efforts have been underway recently to educate people about the heritage and other values of commercial fishing, equally vocal and often more powerful groups have been lobbying against commercial fishing. As recently as July 2013, the North Carolina Marine Fisheries Commission entertained discussion of a petition to close all in-shore waters of North Carolina to shrimp trawling by designating them nursery grounds (Spencer, 2013). While the petition was rejected, it demonstrated the political will of well-organized groups to erecting barriers to commercial fishing in the name of conservation.

As with previous indices, we developed an index of gentrification based on the ways that people we interviewed described their communities. The index was composed of 12 items in the list of characteristics used to describe the communities, including: rapid population growth, heavy traffic, high taxes, high cost of living, a "trendy" scene, and lots of tourism, rich people, second home owners, retirees, natural resource amenities, and golf. We also ranked ports by percentage of people earning $200,000 per year or higher—one of the remote data source methods of estimating gentrification (Table 11).

Again, these figures are in line with our observations, interviews, and general knowledge of these communities. All of the Florida communities, where gentrification is furthest advanced, score above the average of 10.47, while the smaller, more remote communities of Wanchese, Hatteras, and Sneads Ferry all score below the average. In Sneads Ferry and Wanchese, gentrification has been deliberately prevented by repeated organized opposition to community incorporation, which would extend water and sewer services to the coast. There seems to be some agreement, as well, between data from the on-the-ground interviews and some of the data that Jepson and Colburn (2013) used in their study.

One need only to drive through the coastal areas of Florida's coastal communities to see the continued effort to create a "new" waterfront. This is a waterfront, as expressed by interviewees, which caters not to the local population but to visitors and tourists. In fact, in many of the Florida coastal communities visited during the field research, the development of new second homes and condominiums for people from outside the community was commonplace even in what many consider to be a "down" economy. When realtors were asked if they could categorize or identify who the majority of the buyers are, the most common response was "people coming in from out of town either retiring or looking for a second home." The other common response was that people were taking advantage of the low housing costs and buying properties to rent as a part of a supplemental income, but that even many of these people are from "somewhere else."

For the sake of comparison, we took one variable from the data provided in the remote database—percentage of households with incomes of over $200,000 per year—and ranked the communities from most to least gentrified based on this one variable. The comparisons show that the rankings from the two measures are quite similar. The least gentrified port is Wan-

[5]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA

Table 11.—Gentrification by port.

Port	Gentrification score	Rank	$200K inc. %	2nd Rank
Wanchese	3	11	0	16
Hatteras	5	10	n.d.	n.d.
Beaufort	13	4	4.2	6
Morehead City	12	5	1.4	14
Atlantic Beach	12	5	2.1	10
Sneads Ferry	8	9	3.2	9
Wrightsville	14	3	23.7	1
Wilmington	9	8	3.6	7
Little River	5	10	1.7	12
Murrells Inlet	10	7	4.8	5
Charleston	11	6	5.2	4
Savannah	11	6	1.5	13
Brunswick	10	7	1.7	12
St. Simons	13	4	11.8	2
St. Marys	5	10	1.2	15
Fernandina	12	5	4.8	5
St. Augustine	11	6	3.3	8
Cape Canaveral	11	6	1.9	11
Sebastian	12	5	1.2	15
Ft. Pierce	15	2	1.4	14
Palm Beach	18	1	8.4	3
Average	10.47			

chese, and Palm Beach ranked as one of the most, with only two places between the two rankings. Wrightsville Beach, number one in the $200K ranking, is number 3 in the ground-truthing ranking. Murrells Inlet, Little River, St. Augustine, St. Simons, Charleston, Fernandina, Beaufort, and Wilmington were close as well.

With the exception of Palm Beach, however, the Florida communities do not seem so highly gentrified in the second ranking as they emerge in the first. Of course, this is only one variable and not an index. It may also not be the best variable to use in a place like Florida, where many people may not report their income because their homes there are second homes, or where many of the retired have low annual incomes but are actually quite wealthy due to savings, stock portfolios, and the like.

Conclusion

Based on the comparative analysis above, the relationship between the ground-truthed data and the indices developed from publicly available databases correspond to one another—roughly in some cases, more precisely in others—with the former more appropriate to representing the fisheries embedded in large metropolitan centers and the latter most suited to fisheries based in smaller communities. This variation derives from both the ways that social indicators were developed and the nature of South Atlantic fishing communities. Using U.S. census and other databases not explicitly developed to track fisheries runs the risk of including data in the indices that have nothing to do with commercial or recreational fishing. In the occupational data, for example, fishing is counted together with agriculture and forestry, seafood processing workers with light manufacturing workers, and marine suppliers with service workers. Such groupings make it difficult to gauge the true proportion of a working population that fisheries employ, particularly in large metropolitan centers with diversified economies.

A further complicating factor is that many South Atlantic fishing communities are dispersed rather than concentrated, with fishing families' households tucked into neighborhoods with others engaged in other occupations unrelated to fishing. This has occurred, in part, due to gentrification and its influence on property values and taxes, access to waterfront, the growth of leisure uses of the coast that privilege recreational fishing over commercial fishing, and so forth. The dispersal of commercial fishing families across multiple neighborhoods that often results from these processes makes it difficult to rely on census data at the zip code level to estimate fishing dependence and engagement (Jacob et al.[3]). Finding themselves isolated from occupational communities has been the fate of working people around the world. With mill towns largely artifacts, occupational communities have been restricted primarily to occupations dependent on specific local natural resources: fishing, farming, forestry, mining, gathering (e.g., mushrooms, palmetto seeds, and medicinal plants), etc. For this reason, many of the studies of community dependence have been done in regions where reliance on natural resources has a long history (Donahue and Haynes, 2002).

Fishery dependent communities are somewhat different than, say, forestry-dependent or farming-dependent communities, however, in that fishery resources may be more difficult to manage than either forests or agricultural resources. This is due to several of the intrinsic characteristics of fisheries, including their status as common property resources, their susceptibility to developments beyond the control of those who rely on them or those who manage them (e.g., destruction of wetlands or weather-related events), their entanglement in multiple policy issues—from environmental concerns about sea turtles to user conflicts to regulations governing catch shares and marine protected areas—and the vulnerability of slow-maturing species to overfishing (e.g., members of the snapper-grouper complex).

The history of South Atlantic fisheries has produced a diversity of people, firms, families, and communities involved in utilizing fisheries and marine resources. Thus they are utilized by recreational fishermen as a kind of leisure activity, by fishermen who rely on them as a stable source of food, by aquariums for aesthetically pleasing exhibits, and by the highly diverse commercial fishing families and fishing fleets up and down the South Atlantic coast: fleets with hired captains and crews fishing for fish houses who are paid wages; fleets with captains and crews who fish for shares; individ-

ual family fishermen who fish alone or with one or two other family members, sharing the catch; small-scale, community-based fishing families; professional, for-hire charter boat fleets and party boats; etc. These different types of fishing operations are also differentiated by whether they are part-time, seasonal, full-time, or year-round; by whether or not they handle their own seafood marketing; by their relationships to fishery management, etc.

This diversity of social relations makes it difficult to disentangle fishing from the multiple personal and institutional networks in which they operate. This may be one of the reasons that remote data sources fall short of capturing conditions on the ground in some fishing communities; clearly, both the ground-truthing and the remote analysis have advantages and drawbacks, with the former suffering from small sample sizes and the latter from a lack of direct observations that might aid with the interpretation of the data. The above comparative analysis, however, demonstrated that the publicly available data sources and the ground-truthing came to similar conclusions in over two-thirds of the ports studied. Hence, the analysis recommends a hybrid approach, combining both low-cost, rapid assessment using secondary sources with focused interviewing and rapid ethnographic assessment procedures (REAP).

These techniques, moreover, could take advantage of the connections that span regions among different segments of the fisheries and different communities can assist in monitoring changes in fishing communities. We noted earlier that seafood promotion campaigns known as "Catch" programs have brought together fishing families with others interested in preserving community-based fisheries; these, in turn, have spawned Community Supported Fisheries (CSF). In CSF, consumers purchase shares in fishing operations and receive fresh fish regularly, increasing connections between community-based fisheries and the wider public while also exposing consumers to a wider range of seafood than they would normally experience. Here we mention such programs for their potential to serve as windows into fishing communities.

CSF and Catch programs are not alone in stimulating interregional connections. Other examples are seafood alliances and initiatives to promote heritage (e.g., www.saltwaterconnections.org) and protect the privilege of access to marine resources. In these settings are often individuals familiar with multiple fisheries who could easily characterize the problems and challenges that fishing families and communities face. They could, that is, relate developments that influence dependence, engagement, vulnerability, resilience, and sustainability. Such individuals could be recruited much in the same way that, now, NMFS recruits fishermen to observe fishing practices or to monitor marine resources. Once recruited, such individuals could be trained in REAP and assist in the monitoring of fishing communities, creating a cadre of citizen social scientists who could provide information to NMFS on a regular basis. Through such an effort, the mandate of National Standard 8 could be met more fully with timely information.

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Measuring Relationship Marketing Effect in Small-Scale Fishing in Oman and Enhancing Efficiency and Economic Gains for Traditional Fishermen

OMAR al-JABRI, RAY COLLINS, XIMING SUN, SHEKAR BOSE, and RAKESH BELWAL

Introduction

Although Oman's fisheries sector contributes just 0.6% to its national GDP (2011 estimate at 2000 constant prices), its importance in social, economic, and cultural fabrics goes well beyond the statistics. Indeed it plays a pivotal role in Oman's efforts to achieve food security, besides being a cornerstone in its traditional way of life. Under the recent economic diversification efforts, the Sultanate of Oman has devoted significant efforts to devise mechanisms to increase the sector's contribution to the country's GDP, in order to create employment opportunities for Omanis, achieve food security, and sustain community welfare, amongst others (MNE, 2007).

The fisheries sector is comprised of two distinct segments, namely, traditional (or artisanal) and industrial. Fishing activities are carried out exclusively by males. There are seven coastal Governorates in Oman: Musandam, Batinah (North and South), Muscat, Sharqyia South, Wusta, and Dhofar. This study focuses on the small-scale fisheries in the Batinah Governorate.

Total fisheries landings in Oman were estimated at 192,000 t in 2012, of which the traditional sector contributed more than 95% (MAF, 2012). In 2012, the traditional sector alone provided direct employment to 42,553 fishermen, full-time as well as part-time (MAF, 2012)[1]. The traditional sector is comprised predominantly of small-scale fishermen who are engaged in labor-intensive fishing activities with a low level of capital input and technology, and use traditional fishing gears, such as small nets, traps, spears, lines, and hand-collection methods.

Acronyms used in this paper.

MAF	Ministry of Agriculture and Fisheries
MNE	Ministry of National Economy
R&D	Research and Development
FDC	Fisheries Development Centre
OMR	Omani Rial ($1USD = OMR 0.384, fixed exchange rate)

Research Objectives and Justification

Under the notions of supply chain management (SCM) and relationship marketing (discussed in the next section) the main focus of this study is on the post-harvest activities involved in the small-scale fisheries sector of the Batinah Governorate. This is because the existing literature points to several economic inefficiencies in the post-harvest sector that affects the performance of small-scale or traditional fishermen. These

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[1]Further details on the socio-economic contributions of the sector can be found in Bose et al. (2010).

ABSTRACT—This paper aims to measure the effect of relationship marketing and supply chain management practices on small-scale fishermen's incomes on the Batinah coast of the Sultanate of Oman. The study also assesses the potential effects of relevant socio-economic, demographic, and fishing operation related factors on the competitiveness of small-scale fishermen. A field survey was conducted to elicit views of fishermen using two types of questionnaires—one for those fishermen who were engaged in relationship marketing with a preferred buyer, and the other for those fishermen who were not engaged in relationship marketing.

Two factor analyses were conducted with respect to relationship marketing between the fishermen and their preferred buyer and with respect to the supply chain management practices. Further empirical analyses were conducted that involved three main steps. First, the residual from the logistic regression model carried out in a recently published study was computed, where this residual represents the unpredictable component of the fishermen's income. Second, an independent sample t-test was performed to determine any significant differences between the two groups with regard to some relevant variables. Third, the two-stage Heckman procedure was conducted, in which during the first stage the Inverse Mills Ratio (IMR) was computed using the probit model. In the second stage of the Heckman procedure, the residual of the logistic regression (obtained in the first step) was regressed on the IMR and other predictors of relationship marketing related to the fishermen who were engaged in relationship marketing.

Our key finding is that the fishermen who are engaged in relationship marketing and adopt practices of supply chain management have a comparatively higher income and competitive advantage over those who are not engaged in relationship marketing. Therefore, there is a need for strengthening relationships between fishermen and supply chain actors. We hope that the finding will be useful for future planning of the small-scale fisheries in the Batinah Governorates.

inefficiencies may arise from sources including a) market failure, b) lack of control over market supply, c) lack of promotion in developing small-scale fisheries enterprises, d) competition among small-scale fishermen, e) lack of adequate infrastructure and facilities, and f) insufficient attention to product quality (Omezzine, 1998; Al-Jabri, 1999; Al-Oufi et al., 2000; Omezzine et al., 2003). The focus of this study is influenced by the existing claim that effective supply chain management can improve the competitiveness and profitability of actors (Schotzko and Hinson, 2000; Fearne et al., 2001).

The role of supply chain management is crucial for fisheries in Oman as the harvested fish changes hands multiple times before it reaches the end-users. The middlemen (generally truckers) play a significant role in the post-harvest handling and distribution of fish. For example, the middlemen are engaged in transporting and selling fish to local and foreign (neighboring countries) markets. Therefore, a clear understanding of the existing supply chain relationship between fishermen and traders is vital to improve operational efficiency and thereby economic returns to fishermen.

The existing opportunity for enhancing efficiency and economic gains from the post-harvest sector is reflected in the strategic approach stipulated in the government's 5-year plan for the fisheries sector (MNE, 2007). With the establishment of a central wholesale fish market in Barka in the South Batinah Governorate and the development of an action plan for establishing a fisheries industrial estate at Duqm in Wusta Governorate, the Ministry of Agriculture and Fisheries has attempted to address inefficiencies in the supply chain.

The primary objective of this research is to investigate whether engagement in relationship marketing could provide a competitive advantage to fishermen. The published work by Al-Jabri et al. (2013) investigated factors determining income of the small-scale fishermen on Oman's Batinah Coast. It found that fishing inputs, catch, relations with extension services, and other socioeconomic and demographic factors exert positive influence on fishermen's income. All explanatory variables were able to explain 76.4% of the variation in the fishermen's income level. This study furthers the study by Al-Jabri et al. (2013) by investigating whether practices related to SCM and relationship marketing could have additional influence on fishermen's income. Therefore, to address the primary research objective of our study, the analyses are primarily based on the work by Al-Jabri et al. (2013) and investigates to what extent the unexplained variation can be explained by practices related to supply chain management and relationship marketing.

Understanding obstacles affecting supply chains in Oman's fisheries sector and improving their competitiveness is important to this research. This understanding will help in designing solutions to overcome these obstacles and that will lead to improving revenue of the stakeholder and sustainability of the sector.

A Brief Note on Supply Chain Management and Relationship Marketing

Mentzer (2001) argues that the term "supply chain management" (SCM) causes confusion among researchers because it can be viewed as an operational term, a management process, or a management philosophy. He concludes that there should be more effort to identify an exact definition of SCM. Thus, the concept of SCM can be interpreted in different ways, depending on the objectives being addressed by the researcher or the manager, as well as the surrounding circumstances (Mentzer, 2001).

Supply chain management is often defined in terms of managing the flows of products and services—starting from the producer of raw material and ending with the delivery of products to the final customer—through different phases of production and distributional channels using efficient and effective transport, handling, and storage (Schotzko and Hinson, 2000; Dunne, 2001; Collins et al., 2002; Zuckerman, 2002). Food supply and distribution typically requires efficient functioning of a complex set of interrelated activities and services along the supply chain (Shepherd, 1997).

Firms cannot avoid being members of supply chains, and alliances, partnerships, and networks have always existed, though they have only recently been conceptualized as an important part of organized whole-of-chain strategies (Collins et al., 2002). To achieve customer satisfaction in food-business chains, it is necessary to coordinate and form partnerships along the chain so that food products can reach consumers in time as well as in the best quality.

As an integral part of supply chain strategy, relationship marketing plays an important role in managing food supply chains, whether in developed or developing economies. Kurtz (2012:308) defined relationship marketing as "the development, growth, and maintenance of cost-effective, high-value relationships with individual customers, suppliers, distributors, retailers, and other partners for mutual benefit over time". Relationship marketing is based on assuring delivering customer requirements such as low prices, high quality, prompt delivery, and superior service (Kurtz, 2012). Morgan and Hunt (1994:34) refer to relationship marketing as "all marketing activities directed towards establishing, developing, and maintaining successful relational exchanges."

Study Area Profile

The coastline of the Batinah Governorates extends about 270 km along the Sea of Oman and is characterized by a sandy beach with the continental shelf extending up to 30 nmi (Al-Oufi et al., 2000) offshore. In 2012, the Batinah fisheries contributed 16.4% and 25.6% of the total national landings in volume and value, respectively. There were 11,943 registered fishermen in Batinah representing 28% of all registered fishermen in Oman, re-

vealing fisheries as a vital source of income and employment to thousands of families (MAF, 2012). In 2012, the small-scale fishery of the Batinah Governorates represented about 26% of the total number small-scale fishing boats in Oman (MAF, 2012). The Batinah fisheries' share in the country's fish export was about 6% and 4% in volume and value, respectively (MAF, 2011). Overall, the Batinah fisheries provide sustenance to 128 coastal villages in the Governorates.

In terms of landings of species within the Batinah coast, the small pelagic species represented the highest fish landings (about 32.44%) followed by the large pelagic species (about 29.29%) (MAF, 2011). The value of large pelagic species represented about 37% of the total value of landings followed by demersal species (about 32%) in 2011.

Variations in values are influenced by the demand pattern and consumers' taste (MAF, 2011). Most consumers favored large pelagic species such as kingfish, *Scomberomorus commerson*, and tuna, Scombridae, to the extent that they do not like to substitute with other species. While various fishing gears such as gill-net, trolling lines, hand lines, beach seine, and traps are used by fishermen in Oman, gillnets are the most frequently used gear (Al-Oufi et al., 2000).

Local fish markets are characterised by poor infrastructure. In some areas, the fish market is an open area next to the beach where the fishermen land their catch. In the coastal towns, these markets are generally located where fish are landed. Fishermen are automatically linked with markets on the landing sites. Fish markets usually are close to residential areas along with vegetable shops and other markets. Fish landings and selling usually takes place in the morning, however, in some coastal towns, fish markets operate in the afternoon. In these markets, the traders sell what is caught in the afternoon or what is unsold in the morning market.

Common problems such as low prices, inefficient marketing, poor quality control, and poor catch handling exist in the Batinah fishery. Therefore, there is a legitimate concern that if these problems go unresolved, the small-scale fishery might fail to achieve long run sustainability (MAF, 2003).

Methodology

Data Collection

Sample representation is one of the aspects the researchers have taken into account in order to make inferences about the population of small-scale fishermen in the Batinah coast. The sample's representation is determined by the type of data required (Bernard, 2005). Furthermore, the subject matter, the unit of analysis (the fisherman), and scale of the survey govern the choice of the data collection method, while the objective of the survey should determine the methods to be used (Moser and Kalton, 1985). For their sampling process, Masuku and Kirsten (2003) revealed that rather than just ensuring that the sample represented the population, selection criteria should aim to increase the validity of the collected data.

Furthermore, data collected using random sampling for a high number of geographically dispersed and heterogeneous villages may result in high sampling errors and may not be reliable (Al-Oufi, 1999). Without due care, a random sample can be unrepresentative and, together with a population that is not homogeneous, can produce errors; and using a simple random sample may produce high random errors (Al-Oufi, 1999). However, when the population is distributed randomly, randomisation is possible even when using non-probability sampling (Kish, 1995).

Although this research will produce individual data, the objective is to investigate the nature of the relationships between buyers and sellers and to understand the strengths of, and common factors among, fishermen who earn higher incomes. It also seeks an understanding of the commercial behavior of the producers and buyers. With careful attention to the nature of this research and the associated circumstances, it has been judged that probability-sampling techniques would not be appropriate. Non-probability sampling was found to be more suitable for this research to ensure data validity. Therefore, the use of non-probability-judgment sampling is a justified procedure for this research. Based on the research objective, the type of data, and from whom the data should be collected, the procedure will fulfill the requirements of the research.

A field survey was conducted to elicit views of fishermen using two types of questionnaires—one for those fishermen who were engaged in relationship marketing with a preferred buyer, i.e., traders (identified as Group A), and the other for those fishermen who were not engaged in relationship marketing (identified as Group B). As there was no a priori knowledge about individual fishermen's marketing relationships, the interviewers asked the respondents, prior to commencing the interview, if they were involved in any sort of relationship with the traders.

Questionnaires for both the groups (A and B) contained three different sets of questions. The first and second sets, which were common to both groups, sought information on the backgrounds of the respondents, the nature of their participation in the sector, and the nature of their relationship with the Extension Services Department of the Ministry of Agriculture and Fisheries. The third set of questions, which was administered solely to Group A, was designed to collect information on the nature of the relationship between the fishermen and their preferred traders and the current practices in the area of supply chain management. Altogether, the questionnaire contained 64 questions for Group A and 29 questions for Group B respondents.

The majority of questions were dichotomous in nature. To reduce interviewer bias, 53 research assistants (data collectors) were trained to interview 510 fishermen from 110 villages along the Batinah coast. The respondents from both groups were

kept anonymous following the code of conduct by the Ministry of Agriculture and Fisheries, mainly to avoid any inappropriate use of survey information.

There are two major reasons in this research for deciding to use a large number of volunteer data collectors from various villages along the Batinah coast. First is accessibility to fishermen, and second, cost and time constraints. Having over 120 villages scattered along 270 km long coast, with different social and cultural differences, access to fishermen was a major concern to obtain reliable information. Therefore, data collectors were selected from the local area who were enrolled in Sultan Qaboos University. The selected data collectors had the advantage of knowing the region and the fishermen. To ensure data quality, the data collectors were under close supervision and were required to provide day to day feedback at designated control rooms.

Data and Dimension Reduction

A higher number of "non-response" was observed in variables related to income and catch. This was not unusual as it has been commonly observed in socio-economic surveys (Groves et al., 2004). Furthermore, it is noted that these small-scale fishermen were not maintaining records of their income and catch on a regular basis. Finally, following the recommendation by Beale and Little (1975), 39 questionnaires with missing data were eliminated from the analysis to reduce the potential bias.

In an attempt to deal with quantitative measurements of multiple variables, Field's (2005) suggestion was followed and accordingly factor analysis was used as the "dimensionality reducing" technique in this multivariate context. The factor analysis technique has been widely used to overcome the problems of multicollinearity in regression analysis (Batt, 2003). Factor analysis also helped understanding the structure of the dataset as the investigation of relationship marketing involves many components, such as opportunistic behavior, cooperation, information and knowledge, propensity to leave, and power and acquiescence (Morgan and Hunt, 1994).

Two factor analyses were conducted with respect to 1) relationship marketing between the fishermen and their preferred buyer and 2) the supply chain management practices. In the first factor analysis, which was applied to Group A fishermen, 23 variables related to relationship marketing were included. However, the second factor analysis, which was applied to Group A as well, included a set of 15 variables, derived from the supply chain management principles focusing on customers and the right delivery (Collins et al., 2002). These variables were recorded against questions that were asked to assess whether the fishermen were handling their catch in a proper manner and meeting buyers' needs. The factors and their loadings on each variable were determined using the default criteria and the "varimax" method of the SPSS[2] program, respectively.

Econometric Modelling on Relationship Marketing and Its Effect on Fishermen's Income

To conclude whether engaging in relationship marketing could have an impact of fishermen income, several quantitative techniques were adopted. These were done in three steps mentioned below.

Step 1 Computation of Unpredictable Component: Based on an Earlier Study

In this step, we used the study by Al-Jabri et al. (2013) as a basis of further empirical investigation and accordingly the residual is obtained from their estimated logistic regression model. The residual series represents the extent of the unpredictable component (23.6%) and following the objective of this paper, the series is used for subsequent empirical analysis to examine whether the engagement in relationship marketing and adoption of supply chain management practices could explain some of the unexplained (23.6%) variation in fishermen's income.

Step 2 Group Comparison: Independent Sample t-test

An independent sample *t*-test involving Groups A and B was performed based on the average score of relevant variables (including income) that was common to both the groups and was likely to affect the fishermen's economic performance (Table 1 lists these variables) to determine any significant differences between the groups with respect to the variables.

Table 1.—Independent Sample *t*-test.

Variable	Mean A	Mean B	*t*	Sig.
Are you a partner in another fishing boat?	0.373	0.373	0.002	0.998
Is it difficult to obtain ice?	0.147	0.133	-0.255	0.799
Is it difficult to obtain fuel?	0.240	0.241	0.014	0.989
Fisherman's age	38.893	40.277	0.569	0.570
Can you read and write?	0.773	0.687	-1.250	0.222
Is the boat made of fiberglass?	0.773	0.843	1.110	0.269
Do you have another job or source of income?	0.320	0.337	0.230	0.818
Are you the owner of the boat?	0.787	0.747	-0.585	0.559
Do you keep income in-house instead of sharing with the crew (if they are relatives)?	0.093	0.024	-1.831	0.070
Are the crew your relatives?	0.747	0.795	0.723	0.471
Engine power	55.347	50.157	-1.160	0.248
Number of crew	2.267	2.349	0.620	0.536
Average weekly catch	471.467	308.373	-1.354	0.178
Approximately, what is the average annual income from fishing activity?	1895.00	1237.00	-2.655	0.009
Exchange of information and cooperation with MAF (Factor A1)	0.017	0.157	0.922	0.358
Strongly involved with MAF (Factor A2)	0.059	-0.205	-1.684	0.094
Trips per week	7.707	6.964	-1.182	0.239
Total weekly fishing cost	61.75	69.41	0.659	0.511
Boat length	21.13	20.66	-0.958	0.339

[2]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 2.—Probit model coefficients.[1]

Predictor	*b*	S.E.	Z	P[|Z|< z]	Effect size *r*
Trips per week	0.055	0.020	2.799	0.003	0.167
Strongly involved with MAF (Factor A2)	0.175	0.086	2.046	0.021	0.122
Engine Power	0.004	0.005	0.770	0.221	0.046
Boat Length	0.028	0.035	0.816	0.209	0.049
Fisherman age	-0.002	0.007	-0.281	0.390	-0.017
Fisherman thinks of investing in another boat	0.223	0.178	1.251	0.106	0.074
Difficulty getting fuel	-0.146	0.193	-0.754	0.227	-0.045
Difficulty getting Ice	0.203	0.214	0.947	0.174	0.056
Fisherman owns boat	0.271	0.216	1.255	0.105	0.075
Barka	1.647	0.370	4.456	0.000	0.265
Masana'a	1.499	0.353	4.243	0.000	0.253
Suwaiq	1.209	0.318	3.808	0.000	0.227
Khabora	1.017	0.316	3.222	0.001	0.192
Saham	1.364	0.344	3.969	0.000	0.236
Shinas	0.924	0.356	2.596	0.005	0.155
Other sources of income	-0.059	0.188	-0.314	0.378	-0.019
Fisherman can read and write	0.347	0.228	1.521	0.063	0.091
Constant	-2.634	0.717	-3.676	0.000	-0.219

[1]*N* = 282; Pearson Goodness-of-Fit Chi Square = 286.300; DF = 264; p = 0.165.

Step 3 The Heckman Two-stage Procedure

Stage 1: Computing Inverse Mills Ratio It is important to note that when analyzing a subset of the population, censored sampling bias may occur. Therefore, the Heckman procedure was used to construct a selection bias control factor known as the Inverse Mills Ratio (IMR) (Warning and Key, 2002; D'Haese et al., 2005). To compute the IMR, first a dependent (dummy) variable of a relationship group was created where a fisherman in Group A was given a value of "1", and "0" otherwise. A probit model was used and the dependent variable was regressed on potential variables that could determine the probability of a fisherman being from Group A or B (Table 2 lists the variables).[3]

The computed IMR was then used in the second stage of the regression analysis (as discussed below) when estimating the effects of the relationship and supply chain management practices to produce unbiased parameter estimates. The computed IMR was a summary measure that reflected the effects of all unmeasured characteristics related to engagements in relationship marketing. The value of this ratio for each of the respondents was recorded and added, at the same time, to the data file as an additional variable for further analysis (Smits[4]).

Stage 2: Regression Involving Residuals from Step 1 and Relationship Marketing Variables The concluding stage involved linear regression analysis to examine the impact of relationship marketing on fishermen income. This was achieved by using the residuals from the logistic regression, as determined in Step 1, as a dependent variable against the potential factors associated with the relationship marketing and supply chain management.[5] The potential independent variables were grouped before conducting the regression analysis. The purpose of this grouping was to learn what proportion of total variation a set of variables could explain independently.

Results and Discussion

Factor Analysis

The factor analysis involving 23 variables resulted in five factors (B1, B2, B3, B4, and B5) with eigenvalues greater than 1. Factor B1 explained 24.27% of the variance, Factor B2 explained 12.41% of the variance, Factor B3 explained 7.99% of the variance, Factor B4 explained 7.34% of the variance, and Factor B5 explained 6.73% of the variance. Added together, all factors explained 58.74% of the total variance. The grouping of these factors with their underlying items is presented in Table 3. Having Factors B1 and B2 explaining about 37% of the variance indicated the importance of satisfaction and behavior in explaining the phenomena of relationship marketing between the fisherman and the preferred trader.

The second factor analysis, which involved 15 variables, resulted in three factors (C1, C2, and C3). The factor C1, "overall buyer satisfaction with product" explained 29.5% of the variance; factor C2, "adding value" explained 22.2% of the variance; and factor C3, "product differentiation and satisfaction with delivery" explained 14.9% of the variance. Altogether, these factors explained 66.6% of the total variance. The grouping of these factors with their underlying items is presented in Table 4. The results of the factor analysis revealed the importance of factors A1, B1, B2, C1, C2, and C3 in terms of their contribution to the study, as measured by the percentage of variance explained by these factors.

Econometric Modelling

Step 1

We gathered from the results of the logistic model used by Al Jabri et al. (2013) that the model explained 76.4% of variation in the fishermen's income

[3]There is neither theoretical background nor previous research on which variables can predict whether or not a fisherman was engaged in relationship marketing, that is, being a fisherman in Group A or B. In probit models, the independent variables are presumed to affect the choice or category or the choice maker and represent a priori beliefs about the causal or associative elements important in the choice or classification process, the independent variables in this analysis were chosen based on the researcher's presumption that they could predict the dependent variable. The variables entered in the model are the regions, number of weekly trips, engine power, boat length, difficulty of getting ice, difficulty of getting fuel, willingness to invest in another boat, other sources of income, age, ownership of the boat, ability to read and write, and a strong relation with the MAF.

[4]Smits, J. 2003. Estimating the Heckman two-step procedure to control for selection bias with SPSS. Dept. Economics of Nijmegen School of Management, Nijmegen Univ. (Online at http://home.planet.nl/~smit9354/selbias/Heckman-SPSS.doc) (retrieved 8 April 2007)).

[5]Questions relating to supply chain management and relationship marketing were derived from Morgan and Hunt (1994) on relationship marketing, Batt (2003) on trust, Collins et al. (2002) on the principles of supply chain management, and Warning and Key (2002) and D'Haese et al. (2005) on the contribution of being in a relationship to the fishermen's income.

Table 3.—Factor analysis of relationship marketing and trust.

Factor	Factor loading	Initial eigenvalues		
		Total	% of variance	Cumulative %
Factor B1: Relational satisfaction and cooperation		3.641	24.271	24.271
Do you think that your preferred buyer cheats you?	-0.372			
Have you complained (at least once) to your preferred buyer about his commercial behavior toward you?	-0.402			
Is there continuous cooperation between your preferred buyer and yourself?	0.782			
Are you always friendly toward your preferred buyer?	0.633			
Does your preferred buyer always keep his promises?	0.574			
Are you convinced that dealing with this buyer is of benefit to you?	0.731			
Factor B2: Opportunism and commercial behavior		1.862	12.411	36.682
Do you think that your preferred buyer cheats you?	0.511			
Are there frequent disagreements between you and your preferred buyer?	0.714			
Have you complained (at least once) to your preferred buyer about his commercial behavior toward you?	0.387			
Do you agree that you are getting more benefit out of this relationship than if you sold to other buyers?	-0.581			
Do you think that your preferred buyer would not abandon your interests even if there were advantages to him in doing so (that is, is he an opportunist)?	0.586			
Factor B3: Power, dependence, and acquiescence		1.198	7.985	44.667
Have you complained (at least once) to your preferred buyer about his commercial behavior toward you?	0.491			
Must you always do what your preferred buyer tells you?	0.816			
Do you think that if you change and deal with another buyer, you will lose?	0.335			
Do you agree that you are getting more benefit out of this relationship than if you sold to other buyers?	0.446			
Are you highly dependent on this buyer?	0.585			
Factor B4: Sharing value and information		1.101	7.342	52.009
Do you think that your preferred buyer keeps back some useful information for himself?	0.754			
Do you think that the profits of your preferred buyer are much higher than yours?	0.782			
Do you think that your preferred buyer would not abandon your interests even if there were advantages to him in doing so (that is, is he an opportunist)?	0.425			
Factor B5: Propensity to leave and change buyer		1.010	6.732	58.742
Do you think that your preferred buyer cheats you?	0.355			
Do you think that if you change to deal with another buyer, you will lose?	0.531			
Are you highly dependent on this buyer?	0.332			
Do you think that it is not to your benefit to stop dealing with this buyer?	0.826			

levels, and 23.6% of the variation remained unexplained. As mentioned earlier, the residual from the logistic model was computed and used subsequently to investigate how much of the unexplained variation in fishermen's income could be predicted by factors such as "relationship marketing" and "supply chain management practices."

Step 2

Based on 5% significance level (Table 1), out of 19 variables, only the "income" variable indicated a significant difference between the two groups. On average, Group A fishermen (who were engaged in relationship marketing with buyers) experienced higher (about 53.2%) annual incomes than that of Group B. This may suggest group homogeneity with respect to all other variables but income. It led to the conclusion that fishermen in Group A were more competitive than the fishermen in Group B, because they got a better value for their catch due to relationship marketing.

This finding raised a question about the influence of "fisherman-agent" relationship on income. To gain an initial insight on this subject a closed-ended question with the following four potential responses was administered to Group A fishermen to know the type of benefits they gained from their relationship with the preferred trader: 1) a secure income, 2) increased quantity of fish sold, 3) improvement in the quality of catch to meet traders' preference, and 4) better prices.

"Better prices" secured the highest response rate (97.1%), followed by "a secure income," and "an improvement in the quality of catch." Less than one-third of the respondents mentioned

Table 4.—Factor analysis of focusing on customers, adding value, and getting the product right.

Factor	Factor loading	Initial eigenvalues		
		Total	% of variance	Cumulative %
Factor C1: Buyer dissatisfaction with product		2.066	29.510	29.510
Did your preferred buyer complain (at least once) that you did not provide him with enough fish (that is, buyer satisfied with quantity)?	0.815			
Did your preferred buyer complain (at least once) that he did not get the species he wanted (that is, buyer satisfied with species)?	0.804			
Did your preferred buyer complain (at least once) about the quality of your catch (that is, buyer satisfied with quality)?	0.740			
Factor C2: Adding value and quality maintenance		1.555	22.209	51.719
Do you use ice when fishing?	0.857			
Do you have an icebox to keep the catch in your boat or at the landing site?	0.846			
Factor C3: Product differentiation and satisfaction with delivery		1.041	14.866	66.585
Do you grade your fish by size and species before delivery to your preferred buyer (do you provide the buyer with a bulk catch)?	0.893			
Did your preferred buyer show disapproval (at least once) while receiving catch?	0.603			

Table 5.—Group description of predictors of multiple regression with diagnostics.

Model and variable		Cumulative R^2	Successive F-value (d.f.)
Model 1: Maintain product quality and buyer satisfaction	Do you have problems associated with transportation and storage to satisfy the requirements of your preferred buyer?	0.420	5.28 (7, 51)
	Buyer dissatisfaction with product (Factor C1).		
	Adding value and quality maintenance (Factor C2).		
	Product differentiation and satisfaction with delivery (Factor C3)		
	Does the buyer always accept your catch (that is, never rejected)?		
	If your preferred buyer rejects the catch do you bring it to the market immediately or call another buyer?		
Model 2: Trust	How confident are you that your preferred buyer is trustworthy?	0.543	3.17 (4, 47)
	Opportunism and commercial behavior (Factor B2).		
	Power, dependence, and acquiescence (Factor B3).		
	Propensity to leave and change buyer (Factor B5).		
Model 3: Sharing value and information	Do you often discuss future demand for fish with your preferred buyer?	0.643	2.98 (4, 43)
	Do you have minimum knowledge of the customers and selling prices of your preferred buyer?		
	In your opinion, do you agree that sharing information is the reason for the success of this relationship?		
	Sharing value and information (Factor B4).		
Model 4: Familiarity and association with buyer	Is this buyer a trucker/agent?	0.725	2.93 (4, 39)
	Do you deal with this preferred buyer because he is a friend and a known person?		
	How long have you been selling to the preferred buyer named above?		
	How often, per week, do you sell your catch to this named buyer?		
Model 5: Agreement and trading	Do you have an agreement that the catch is only for him?	0.773	3.87 (2, 37)
	Approximately, what is the percentage of your sales to this buyer?		
Overall summary statistics	Durbin-Watson: 2.83		

that they experienced a gain in the quantity of fish sold. These findings indicated that the fishermen in Group A gained competitive advantage because of the high prices they received.

Step 3

Computing of the IMR From the probit model (Table 2), the Inverse Mills Ratio (IMR) was calculated. There were some unobserved factors that could increase the probability of engaging in a relationship with a buyer, which could be indicated by the concluded significance of the IMR. The model shows that the IMR turned out to be statistically insignificant at the 5% level. The non-significance of the Inverse Mills Ratio ruled out the possibility of any censored sampling bias in estimating the parameters (Warning and Key, 2002; D'Haese et al., 2005).

Linear Regression of the Residual

Accordingly, five groups of predictors were proposed and entered as blocks to the model (Table 5). These five blocks included maintain product quality and buyer satisfaction, trust, agreement and trading, sharing value and information, and familiarity and association with buyers. As shown in Table 5, variables under the "maintain product quality and buyer satisfaction" categories included the predictors on product quality and storage, which produces R^2 value of 0.420 and the corresponding F-ratio of 5.278 was significant at the 5% level. Model 1 therefore, explained 42% of the variance in the dependent variable.

Because the residual counted for 23.6% of the unexplained variance, so the predictors of quality, product, and storage counted for 9.9% (0.42 × 23.6) of the variance in fishermen's income levels. This result indicated the importance of delivering products that buyers expect. It also indicated the importance of maintaining quality through the use of ice and iceboxes during storage and transportation.

The variables representing trust in Model 2 caused R^2 to change from 0.420 to 0.543, with a significant F-ratio of 3.169, at the 5% level. The predictors in Block 2 explained 12.3% of the variance in the dependent variable, which accounted for (0.123 × 23.6) 2.9% of the variance in fishermen's income levels. This indicated that mutual trust between the fisherman and his preferred trader can affect fishermen's income. Adding "sharing value and information" as a predictor further caused R^2 to change from 0.543 to 0.643. This addition changed the F-ratio to 2.984, which was significant at the 5% level. The predictors in Model 3 explained almost 10% of the variance in the dependent variable. Therefore, "sharing value and information" accounted for approximately 2% (0.099 × 23.6) of the variance in fishermen's income.

Model 4 caused an increase in R^2 value to 0.725. The change was significant at the 5% level with an F-ratio of 2.927. Being familiar with the buyer and the social capital built through the relationship explained 8.3% of the variance in the dependent variable, which accounted for (0.083 × 23.6) about 2% of variance in the fishermen's income.

Finally, Model 5 on the type of agreement and trading caused R^2 to change from 0.725 to 0.773, with a significant F-ratio of 3.870, at the 5% level. The predictors of Block 5 explained 4.8% of the variance in the residual. Therefore, the nature of the agreement and the amount of catch sold to the buyer accounted for 1.1% of variance in the fishermen's income level.

Therefore, regression analysis of variables on the nature of relationship between the fisherman and practices of supply chain management was able to explain 77.3% (R^2) of the unexplained variance (the residual) of logistic regression analysis on the fishermen's income level. This indicated

Table 6.—Results of the multiple regression model.

Variable	*B*	S.E	Beta	*t*	Sig.
(Constant)	-0.604	0.143		-4.219	0.000
Inverse Mills Ratio (LAMBDA)	0.043	0.075	0.055	0.577	0.567
Do you have problems associated with transportation and storage to satisfy the requirements of your preferred buyer? Q13	0.043	0.043	0.111	0.992	0.328
Adding value and quality maintenance (Factor C2)	0.176	0.022	0.892	7.870	0.000
Buyer dissatisfaction with product (Factor C1)	-0.036	0.020	-0.209	-1.831	0.075
Product differentiation and satisfaction with delivery (Factor C3)	0.015	0.021	0.077	0.723	0.474
Does the buyer always accepts your catch (that is, never rejected) (Q8)	0.172	0.130	0.200	1.324	0.194
If your preferred buyer rejects the catch do you bring it to the market immediately or call another buyer? (Q7)	0.240	0.104	0.354	2.311	0.026
How confident are you that your preferred buyer is trustworthy? (Q23)	0.083	0.041	0.212	2.022	0.050
Opportunism and commercial behavior (Factor B2)	-0.040	0.017	-0.220	-2.333	0.025
Power, dependence, and acquiescence (Factor B3)	-0.011	0.019	-0.063	-0.596	0.555
Propensity to leave and change buyer (Factor B5)	0.017	0.025	0.077	0.691	0.494
Do you have an agreement that the catch is only for him? (Q6)	0.094	0.041	0.211	2.277	0.029
Approximately, what is the percentage of your sales to this buyer? (Q10)	0.002	0.001	0.188	1.897	0.066
Do you often discuss future demand for fish with your preferred buyer? (Q19)	0.065	0.054	0.133	1.194	0.240
Do you have minimum knowledge of the customers and selling prices of your preferred buyer? (Q21)	0.126	0.038	0.394	3.331	0.002
In your opinion, do you agree that sharing information is the reason for the success of this relationship? (Q37)	0.061	0.044	0.126	1.387	0.174
Sharing value and information (Factor B4)	-0.019	0.022	-0.099	-0.894	0.377
Is this buyer a trucker/agent? (Q3)	0.079	0.045	0.178	1.738	0.090
Do you deal with this preferred buyer because he is a friend and a known person? (Q5)	0.076	0.045	0.200	1.711	0.096
How long have you been selling to the preferred buyer named above? (Q4)	-0.009	0.004	-0.255	-2.483	0.018
How often, per week, do you sell your catch to this named buyer? (Q9)	-0.008	0.014	-0.066	-0.550	0.586

N = 59 (Group A).

that 18.2% (23.6 × 0.773) of the variance in the income level of fishermen from Group A was explained by these variables.

From the above analysis we concluded that the overall contribution of engaging in supply chain management practices and maintaining a good relationship with traders, associated with trust and good manners, explained 18.2% of the variance in income of the fishermen. This indicated that fishermen's engagement in relationship marketing and supply chain management practices could improve their income by 18.2%.

The regression model results, as shown in Table 6, highlight the important factors in each block that contributed significantly to the final model. The significance of Factor C2 (even at 1% level) indicates the importance of quality in the determination of small-scale fishermen's income in the Batinah coast, particularly in the area of supply chain management. The data also reveal that despite being statistically insignificant, buyer dissatisfaction makes a negative impact on fishermen's income. These two findings altogether indicate that focusing on customers and final consumers, in addition to delivering the right products, is important for the income of the small-scale fishermen in the Batinah Governorates. Furthermore, maintaining good relations with more than one buyer is important, especially when a single buyer refuses to accept the entire catch. As a result, a fisherman would not be forced to discard his catch.

Trusting the preferred buyer was found to have a positive relationship with income. Building trust between both the fisherman and the buyer improved mutual understanding and led to a higher number of deals between them. On the contrary, opportunistic behavior was found to be negatively related to income. Opportunistic behavior reduced trust and caused parties to rethink before the deals, and decreased the number or amount of transactions in the long run.

Holding relationships with different buyers provided more opportunities for outlets for the product. Having some knowledge of the downstream customers of the preferred buyer and the deals (prices) was found to be highly significant in predicting income level. This knowledge provided fishermen an opportunity to avoid selling below market price.

Results revealed that sharing information, which was also a reason for successful relationships, showed positive relationships with income. These findings showed that sharing information between the partners in the supply chain was important in relationships and could improve income. It was also found that over a period of time, as the relationship with the buyer increased, social capital was established and relations became stronger, which in turn, induced discounts and prevented bargaining on prices.

Fishermen's income was found to be higher in cases where they agreed to sell their entire catch to a single buyer. Alternatively, the proportion of a fisherman's catch sold to the buyer was found to be positively related to income, i.e., a higher percentage meant higher income. This implied the importance of maintaining a good relationship to guarantee better income.

Conclusion and Recommendations

One of the strategic objectives of the fisheries sector in Oman is to enhance the income of the traditional fishermen (MNE, 2007). Giving primary consideration to this strategic objective, our study ascertains the important role that the fishermen-trader arrangements can play on the income of the traditional fishermen in the study area. However, the study does not claim that the end results are ideal. This is be-

cause the existing fishermen-trader marketing relationship is not mature and lacks transparency in the determination of price, quality, and quantity as the results of these activities failed to show up in national statistics. These factors are likely to cause market imperfections, and thereby lead to inefficient results. Therefore, appropriate strategic actions seem desirable to improve fishermen's share in output price and improve marketing systems.

There are various approaches that can be followed to attend to market imperfections. One approach to addressing market imperfections is through institutionalizing the fishermen-trader arrangements in a collaborative manner and shaping up the arrangements through regulatory measures and incentives (such as providing infrastructures, access to improved technology, etc.) so that such arrangements can generate the most economic value to society, and fishermen can negotiate the price of their products with a greater degree of transparency.

Another approach is to create opportunities for fishermen to access markets and obtain competitive price for their harvests. This option was adopted by the Ministry of Agriculture and Fisheries in April 2014, when it formally established the central wholesale fish market in Al-Batinah Governorate with a goal of improving the fish marketing system in Oman.

The main reasons for the establishment of the wholesale market include, among others, boosting fishermen's income by giving them access to the market to get fair price for their products through competitive bidding and ensuring product quality to protect consumers' health and well-being. This strategic action is certainly a significant step in the right direction as the initiative has the potential for correcting the extent of existing imperfections in the post-harvest sector.

However, to reap the benefits of such strategic action and achieve the intended objectives of the sector stipulated in the 5-year plan appropriate regulatory measures need to be taken to improve its operational efficiency so that the market can meet its economic objectives, and the effort needs to be intensified by including other coastal governorates. The authorities should play an active role in raising awareness among fishermen regarding the potential of the wholesale establishment to improve their economic situation in the long run. Furthermore, it is envisaged that improvement in transportation and storage facilities will play a significant role in improving fishermen's income through preserving product quality.

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Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to the *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700 (available from the SPO website).

Manuscripts must be double-spaced throughout, and a complete manuscript normally includes a title page, a short abstract, text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, headings, subheadings, and the abstract short and clear. Because abstracts are circulated by abstracting agencies, it is important that they represent the research clearly and concisely. Headings within each section must be short, reflect a logical sequence, and follow the rules of multiple subdivision (i.e., there can be no subdivision without at least two items).

Style

The entire text should be intelligible to interdisciplinary readers; therefore, all acronyms, abbreviations, and technical terms should be spelled out the first time they are mentioned. The scientific names of species must be written out the first time they are mentioned; subsequent mention of scientific names may be abbreviated. Follow the U.S. Government Printing Office Style Manual (2008 ed.) and the Scientific Style and Format: the CSE Manual for Authors, Editors, and Publishers (2014, 8th ed.) published by the Council of Science Editors.for editorial style, and the most current issue of the American Fisheries Society's Common and Scientific Names of Fishes from the United States and Canada for fish nomenclature. Only journal titles, scientific names (genera and species), and vessel names should be italicized. Dates should be written as follows: 11 November 2013. Measurements should be expressed in metric units, e.g., metric tons as (t); other equivalent units may also be listed in parenthesis. Common abbreviations and symbols such as mm, m, g. ml, mg, and °C (without periods) may be used with numerals. The numeral one (1) should be typed as a one, not as a lower-case el (l). Write out the numbers zero through nine unless they form part of measurement units (e.g., nine fish but 9 mm).

Footnotes

Footnotes should not be embedded within the text document. They must be numbered with Arabic numerals and listed separately. Footnote all personal communications, unpublished data, and unpublished manuscripts with full address of the communicator or author, or, as in the case of unpublished data, where the data are on file. Authors are advised to avoid references to nonstandard (gray) literature, such as internal, project, processed, or administrative reports, wherever possible. Where these references are used, please include where they may be located (website or public depository).

Tables

Tables should be printed separately and double-spaced. Tables should not be excessive in size and must be cited in numerical order in the text. Headings should be short but ample enough to allow the table to be intelligible on its own. All unusual symbols must be explained in the table heading. Other incidental comments may be footnoted with Arabic numerals. Because tables are typeset, they need only be submitted typed and formatted, with double-spaced legends. Zeros should precede all decimal points for values less than one. Table headings and format should be consistent; do not use vertical rules.

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Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1979a, 1979b, 1979c, etc.). Authors must double-check all literature cited; they alone are responsible for its accuracy.

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Finally

Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission.

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